



**U.S. Department of Energy
Hanford Site**

August 10, 2020

20-SGD-0062

Ms. Alexandra K. Smith, Program Manager
Nuclear Waste Program
Washington State Department of Ecology
3100 Port of Benton Boulevard
Richland, Washington 99354

Dear Ms. Smith:

**INTERIM STATUS GROUNDWATER MONITORING PLAN FOR SINGLE-SHELL TANK
WASTE MANAGEMENT AREA A-AX, DOE/RL-2019-44, REVISION 0**

This letter transmits the Interim Status Groundwater Monitoring Plan for Single-Shell Tank Waste Management Area A-AX Report, DOE/RL-2019-44, Revision 0 to the Washington State Department of Ecology.

If you have any questions, please contact me, or your staff may contact, Doug Hildebrand, of my staff, on (509) 373-9626.

Sincerely,

Michael W. Cline Digitally signed by Michael W.
Cline
Date: 2020.08.10 08:20:31 -0700

Michael W. Cline, Director
Soil and Groundwater Division
Richland Operations Office

SGD:RDH

Attachment

cc: See page 2

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Interim Status Groundwater Monitoring Plan for the Single-Shell Tank Waste Management Area A-AX

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management



P.O. Box 550
Richland, Washington 99352

Interim Status Groundwater Monitoring Plan for the Single-Shell Tank Waste Management Area A-AX

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APPROVED

By Janis D. Aardal at 3:48 pm, May 28, 2020

Release Approval

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Terms

AEA	<i>Atomic Energy Act of 1954</i>
DOE	U.S. Department of Energy
DWMU	dangerous waste management unit
Ecology	Washington State Department of Ecology
EER	engineering evaluation report
FWS	Field Work Supervisor
QAPjP	quality assurance project plan
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
TOC	total organic carbon
TOX	total organic halogen
Tri-Party Agreement	<i>Hanford Federal Facility Agreement and Consent Order</i>
VOC	volatile organic compounds
WMA	waste management area

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1 Introduction

This document presents a groundwater monitoring program for Waste Management Area (WMA) A-AX, and when issued into the operating record, becomes the principal controlling document for conducting groundwater monitoring under the dangerous waste regulations (WAC 173-303, “Dangerous Waste Regulations”) at WMA A-AX, superseding the previous plan (DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX*).

This groundwater monitoring plan is based on the requirements for interim status facilities, as defined by the *Resource Conservation and Recovery Act of 1976* (RCRA), with regulations promulgated by the Washington State Department of Ecology (Ecology) in the *Washington Administrative Code* and the *Code of Federal Regulations* by reference (WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards”; 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring”). This plan is required by 40 CFR 265.90(a) and (b), “Applicability,” and is intended to satisfy groundwater monitoring requirements applicable to interim status treatment, storage, and disposal units (referred to as dangerous waste management units [DWMUs] in this plan), and monitors for indicator parameters in groundwater samples that are used to determine whether dangerous waste or dangerous waste constituents have entered the groundwater. This plan also monitors parameters used in establishing groundwater quality.

The U.S. Department of Energy (DOE) is revising the groundwater monitoring plan for WMA A-AX to return the unit to an indicator parameter monitoring program based on the results of the recent groundwater quality assessment and add two new wells to the monitoring network. In 2005, WMA A-AX entered a groundwater quality assessment monitoring program under 40 CFR 265.93, “Preparation, Evaluation, and Response,” due to an exceedance of specific conductance at a downgradient well. In 2016, a revised groundwater monitoring plan (i.e., DOE/RL-2015-49) was issued to update the well network with replacement well 299-E25-237 and revise the monitoring constituents. In 2019, the first determination report (DOE/RL-2019-21, *Groundwater Assessment First Determination Report for Waste Management Area A-AX*) did not definitively identify any dangerous waste constituents in groundwater that were attributable to WMA A-AX; therefore, monitoring of the unit is being returned to an indicator parameter monitoring program as described in this plan.

WMA A-AX is an inactive single-shell tank farm located in the 200 East Area of the Hanford Site (Figure 1-1) and overlies the 200-PO-1 Groundwater Operable Unit. WMA A-AX includes 10 single-shell tanks and ancillary equipment of the 241-A and 241-AX Tank Farms that were used for storage of neutralized acidic wastes from the Plutonium-Uranium Extraction and B Plants. In accordance with Section I.A of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (hereinafter referred to as the Hanford Facility RCRA Permit), WMA A-AX will continue under interim status until it is incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit (or its successor) or until interim status is terminated. Therefore, groundwater monitoring for WMA A-AX continues under interim status requirements. For regulatory purposes, the boundary of WMA A-AX is identified on the Hanford Facility RCRA Permit Part A Form.

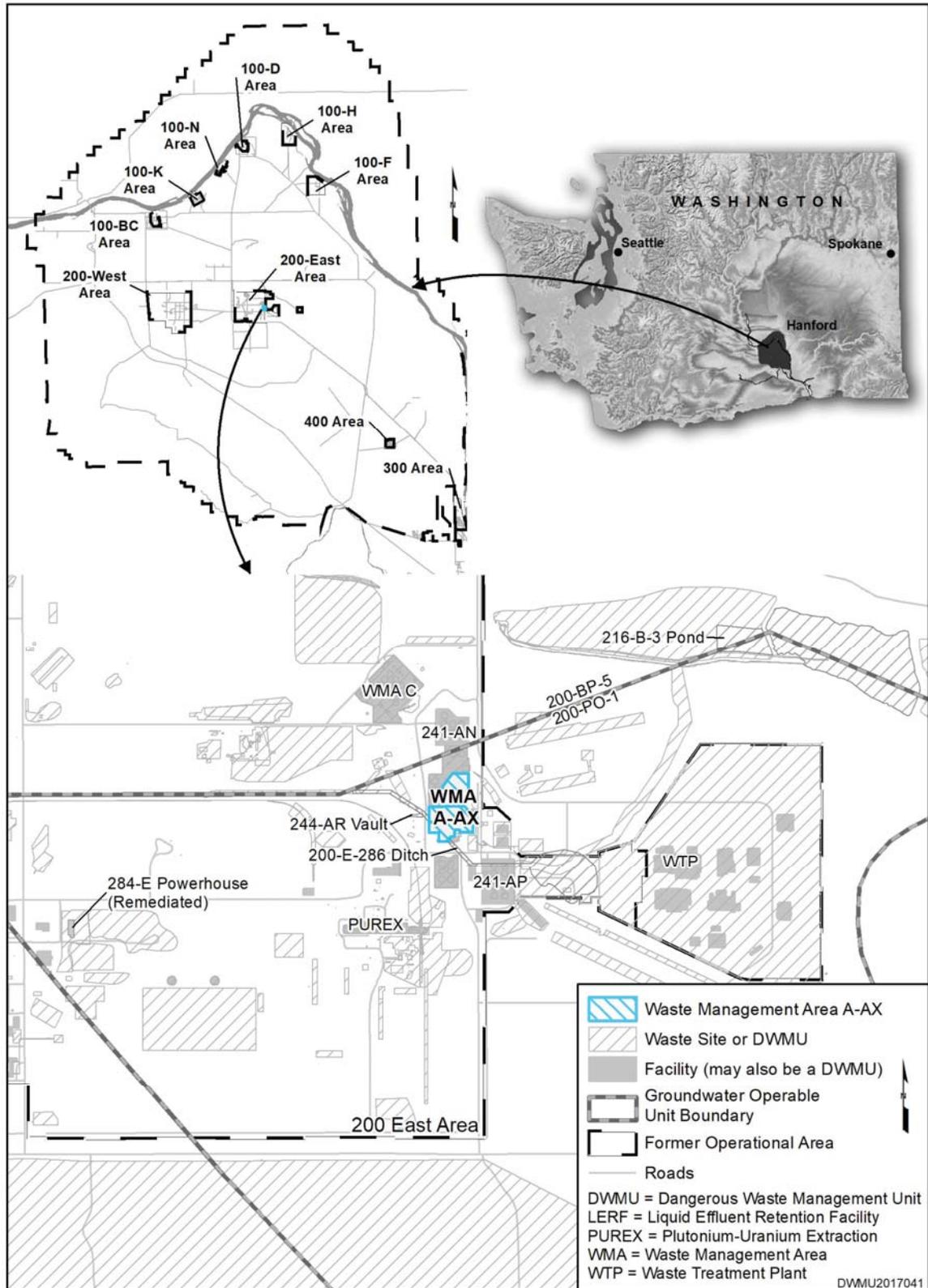


Figure 1-1. Location Map for WMA A-AX

SGW-60586, *Engineering Evaluation Report for Single-Shell Tank Waste Management Area A-AX Groundwater Monitoring*, is one of a suite of groundwater monitoring engineering evaluation reports (EERs) for regulated units located within the Hanford Site Central Plateau that were prepared to support Part B (final status) permit application material for the future Revision 9 of WA7890008967, *Hanford Facility Dangerous Waste Permit (Site-Wide Permit)* (hereinafter referred to as the Hanford Sitewide Permit). The EERs do not create any groundwater monitoring requirements; however, they contain the most comprehensive background information supporting groundwater monitoring to date for each regulated unit. Detailed area-wide and unit-specific groundwater evaluation methodology was used to assess the locations of existing wells and propose locations for new wells that would detect groundwater contamination that may occur from each regulated unit. For WMA A-AX, analysis of groundwater elevations and contaminant particle-tracking calculations, as well as an evaluation of vertical contaminant migration in groundwater, were performed to evaluate the existing monitoring well networks and propose locations for two new monitoring wells.

Regular updates to the EERs are planned as new data become available and changes to groundwater conditions are identified. Because regular updates to the EERs will ensure that they remain the most updated source for unit-specific information related to groundwater monitoring (i.e., hydrogeologic conditions, contaminant migration conceptual models, etc.), the detailed information specific to WMA A-AX that is provided in SGW-60586 is included only by reference in this interim status groundwater monitoring plan.

One of the primary objectives of the EERs is to identify a well network for the monitoring that is required at a final status unit under WAC 173-303-645, “Releases from Regulated Units.” At WMA A-AX, the proposed final status network also meets the requirements for monitoring under the interim status requirements of WAC 173-303-400 and 40 CFR 265, Subpart F; therefore, the well network proposed in SGW-60586 is incorporated into this plan. Table 1-1 identifies the locations where information pertinent to this groundwater monitoring plan is presented in SGW-60586.

This groundwater monitoring plan includes the following chapters and appendices:

- Chapter 2 describes the groundwater monitoring program, including the wells in the monitoring network, constituents analyzed, and sampling frequency.
- Chapter 3 describes data evaluation and reporting.
- Chapter 4 provides an outline for a groundwater quality assessment plan.
- Chapter 5 contains the references cited in this plan.
- Appendix A provides the quality assurance project plan (QAPjP) and the analytical methods for WMA A-AX sampling constituents.
- Appendix B contains sampling protocols.
- Appendix C provides information for the wells within the groundwater monitoring network.

Table 1-1. Locations of Pertinent Supporting/Background Information in SGW-60586, Engineering Evaluation Report for Single-Shell Tank Waste Management Area A-AX Groundwater Monitoring

Section/ Subsection	Title/Topic
2.1	Background
2.1.1	Facility Description
2.1.2	Operational History
2.1.3	Single-Shell Tanks and Liquid Handling Structures within WMA A-AX
2.1.4	Unplanned Releases
2.3	Waste Characteristics
2.4	Interim Status Monitoring Network and Sampling History
3.1	Stratigraphy
3.2	Hydrogeology
3.3	Groundwater Flow System
4	Contaminant Migration Conceptual Model
4.1	Vadose Zone
4.2	Soil Moisture Factors
4.3	Hydrogeologic Considerations
4.4	Subsurface Chemistry
5	Calculation Methods
6	Calculations
7	Simulation Results and Conclusions
9.3	Proposed Groundwater Monitoring Network
9.3.1	Groundwater Monitoring Well 299-E24-20
9.3.2	Groundwater Monitoring Well 299-E24-22
9.3.3	Groundwater Monitoring Well 299-E24-23
9.3.4	Groundwater Monitoring Well 299-E25-40
9.3.5	Groundwater Monitoring Well 6299-E25-41
9.3.6	Groundwater Monitoring Well 299-E25-93
9.3.7	Groundwater Monitoring Well 299-E25-94
9.3.8	Groundwater Monitoring Well 299-E25-237
9.3.9	Groundwater Monitoring Well WMA_A-AX_PW-1
9.3.10	Groundwater Monitoring Well WMA_A-AX_PW-2

1.1 Regulatory Basis

In May 1987, DOE issued a final rule (10 CFR 962, “Byproduct Material”) stating that the hazardous waste components of mixed waste are subject to RCRA regulations. Ecology gained regulatory authority over the hazardous waste components of mixed waste on August 19, 1987.

In May 1989, DOE, the U.S. Environmental Protection Agency, and Ecology signed Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement). This agreement established the roles and responsibilities of the agencies involved in regulating and controlling remedial restoration of the Hanford Site, which includes WMA A-AX. Under interim status, groundwater monitoring at WMA A-AX has been conducted in accordance with WAC 173-303-400(3), “Dangerous Waste Regulations,” “Interim Status Facility Standards” (and, by reference, 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring”), which requires monitoring to determine whether dangerous waste constituents from the DWMU have entered the groundwater in the uppermost aquifer underlying the unit.

Dangerous waste is regulated under RCW 70.105, “Hazardous Waste Management,” and its Washington State implementing regulations (WAC 173-303). Radionuclides in mixed waste may include “source, special nuclear, and byproduct materials” as defined in the *Atomic Energy Act of 1954* (AEA). The AEA states that these radionuclide materials are regulated at DOE facilities, exclusively by DOE, acting pursuant to its AEA authority. Radionuclide materials are not hazardous/dangerous wastes and, therefore, are not subject to regulation by the State of Washington under RCRA or RCW 70.105.

An interim status indicator parameter groundwater monitoring program (WHC-SD-EN-AP-012, *40 CFR 265 Interim-Status Ground-Water Monitoring Plan for the Single-Shell Tanks*) was initiated in 1989 at WMA A-AX in accordance with 40 CFR 265, Subpart F (as referenced by WAC 173-303-400(3)). The indicator parameter monitoring program continued until 2005, when WMA A-AX was placed into a groundwater quality assessment monitoring program in accordance with 40 CFR 265.93(d), “Preparation, Evaluation, and Response.” The groundwater quality assessment was required because specific conductance results in downgradient well 299-E25-93 exceeded the upgradient critical mean¹ in June 2005 (Section 1.1 in PNNL-15315, *RCRA Assessment Plan for Single-Shell Tank Waste Management Area A-AX at the Hanford Site*).

In 2010, a first determination report (SGW-47538, *Groundwater Quality Assessment Report for Waste Management Area A-AX: First Determination*) was issued. The report found that elevated concentrations of nitrate and technetium-99 could have originated from WMA A-AX and that nickel, a dangerous waste constituent detected at elevated levels in downgradient wells 299-E25-40 and 299-E25-236, had originated from WMA A-AX (Section 4 in SGW-47538).

In 2016, a revised groundwater quality assessment plan (DOE/RL-2015-49) was issued that updated the well network and monitoring constituents, and presented findings related to elevated nickel measured in groundwater samples (Sections 2.2, 2.5.1, and 2.5.2 in DOE/RL-2015-49). In 2012, a short-term increase in nickel concentrations in well 299-E25-236 was definitively associated with casing corrosion, as supported by a visual inspection of the interior of the well using a downhole video survey that showed significant corrosion. A video survey inside the casing of well 299-E25-40 was also performed in 2012 but did not show distinct corrosion characteristics (Sections 2.5.1 and 2.5.2 in DOE/RL-2015-49).

¹ The critical mean is a statistically determined background value that is calculated as specified under 40 CFR 265.93(b) and is used to determine if indicator parameters exhibit a significant increase (or pH decrease) in downgradient wells.

Elevated metal concentrations in these wells were determined to be the result of stainless steel well casing corrosion and not a release from WMA A-AX (Section 2.2 in DOE/RL-2015-49). In 2017, a video survey of well 299-E25-41 identified a black residue at the bottom of the screen, just above the sump.

Nickel concentrations in the well have been historically variable, but an overall increasing trend has been apparent since 2016. Details of the groundwater monitoring history at the unit are available in Section 2.4 of SGW-60586.

In 2019, the first determination report (DOE/RL-2019-21), which evaluated quarterly sampling from March 2016 through June 2018, was prepared. During this time, specific conductance levels continued to increase in each of the WMA A-AX network wells (i.e., both upgradient and downgradient) (Chapter 4 in DOE/RL-2019-21). Based on the evaluation process, seven potential dangerous waste/dangerous waste constituents evaluated for assessment (chloroform, chromium, copper, nickel, octachlorodibenzo-p-dioxin, sulfide, and vanadium) required further evaluation (Chapter 4 in DOE/RL-2019-21). After consideration of data quality, upgradient and downgradient concentration comparisons, substrate geochemistry, and stainless steel corrosion conditions within specific wells, it was concluded that no dangerous waste constituents in groundwater were associated with the WMA A-AX (Chapter 4 in DOE/RL-2019-21).

Based on the findings of the first determination report, groundwater monitoring at WMA A-AX is returned to an indicator parameter program under this monitoring plan. Additional constituents that were recommended for monitoring in Chapter 4 of DOE/RL-2019-21 (chloroform, metals, anions, and field parameters) are also included in this plan.

1.2 Monitoring Objectives

The objective of the groundwater monitoring program at WMA A-AX is to determine the facility's impact, if any, on the quality of the underlying groundwater. This groundwater monitoring plan addresses specifically those applicable RCRA requirements for interim status DWMUs where no impact to groundwater has been identified. The regulatory requirements applicable to this groundwater monitoring plan are found in WAC 173-303-400(3) and 40 CFR 265.90, "Applicability," through 40 CFR 265.94, "Recordkeeping and Reporting." Table 1-2 identifies where each groundwater monitoring element of the pertinent regulations is addressed within this plan.

Table 1-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement^a	Section Where Requirement is Addressed in Monitoring Plan
Applicability	40 CFR 265.90, "Applicability" (a) Within one year after the effective date of these regulations, the owner or operator of a surface impoundment, landfill, or land treatment facility which is used to manage hazardous waste must implement a ground-water monitoring program capable of determining the facility's impact on the quality of ground water in the uppermost aquifer underlying the facility, except as §265.1 and paragraph (c) of this section provide otherwise. (b) Except as paragraphs (c) and (d) of this section provide otherwise, the owner or operator must install, operate, and maintain a ground-water monitoring system which meets the requirements of §265.91, and must comply with §§265.92 through	Chapter 1

Table 1-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement^a	Section Where Requirement is Addressed in Monitoring Plan
	265.94. This ground-water monitoring program must be carried out during the active life of the facility, and for disposal facilities, during the post-closure care period as well.	
Number and location of wells	<p>40 CFR 265.91, “Ground-Water Monitoring System”:</p> <p>(a) A ground-water monitoring system must be capable of yielding ground-water samples for analysis and must consist of:</p> <p>(1) Monitoring wells (at least one) installed hydraulically upgradient (i.e., in the direction of increasing static head) from the limit of the waste management area. Their number, locations, and depths must be sufficient to yield ground-water samples that are:</p> <p>(i) Representative of background ground-water quality in the uppermost aquifer near the facility; and</p> <p>(ii) Not affected by the facility; and</p> <p>(2) Monitoring wells (at least three) installed hydraulically downgradient (i.e., in the direction of decreasing static head) at the limit of the waste management area. Their numbers, locations, and depths must ensure that they immediately detect any statistically significant amounts of dangerous waste or dangerous waste constituents that migrate from the waste management area to the uppermost aquifer.</p>	Section 2.2 and Table 2-4
Well configuration	<p>40 CFR 265.91:</p> <p>(c) All monitoring wells must be cased in a manner that maintains the integrity of the monitoring well bore hole. This casing must be screened or perforated, and packed with gravel or sand, where necessary, to enable sample collection at depths where appropriate aquifer flow zones exist. The annular space (i.e., the space between the bore hole and well casing) above the sampling depth must be sealed with a suitable material (e.g., cement grout or bentonite slurry) to prevent contamination of samples and the ground water.</p> <p>Additional requirements from WAC 173-303-400(3)(c)(v)(C), “Dangerous Waste Regulations,” “Interim Status Facility Standards”:</p> <p>Ground water monitoring wells must be designed, constructed, and operated so as to prevent ground water contamination. Chapter 173-160 WAC may be used as guidance in the installation of wells.</p>	Section 2.2 and Appendix C
Sample protocols Analytical methods	<p>40 CFR 265.92:</p> <p>(a) The owner or operator must obtain and analyze samples from the installed ground-water monitoring system. The owner or operator must develop and follow a ground-water sampling and analysis plan. He must keep this plan at the facility. The plan must include procedures and techniques for:</p> <p>(1) Sample collection;</p>	Appendix A, Section A3 and Appendix B, Sections B2 through B5

Table 1-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement^a	Section Where Requirement is Addressed in Monitoring Plan
	(2) Sample preservation and shipment; (3) Analytical procedures; and (4) Chain of custody control.	
Parameters to be sampled Frequency of sampling Water-level measurements	40 CFR 265.92, "Sampling and Analysis": (b) The owner or operator must determine the concentration or value of the following parameters in ground-water samples in accordance with paragraphs (c) and (d) of this section: (1) Parameters characterizing the suitability of the ground water as a drinking water supply, as specified in Appendix III ^b . (2) Parameters establishing ground-water quality: (i) Chloride (ii) Iron (iii) Manganese (iv) Phenols (v) Sodium (vi) Sulfate [Comment: These parameters are to be used as a basis for comparison in the event a ground-water quality assessment is required under §265.93(d).] (3) Parameters used as indicators of ground-water contamination: (i) pH (ii) Specific conductance (iii) Total organic carbon (iv) Total organic halogen (c)(1) For all monitoring wells, the owner or operator must establish initial background concentrations or values of all parameters specified in paragraph (b) of this section. He must do this quarterly for one year. (2) For each of the indicator parameters specified in paragraph (b)(3) of this section, at least four replicate measurements must be obtained for each sample and the initial background arithmetic mean and variance must be determined by pooling the replicate measurements for the respective parameter concentrations or values in samples obtained from upgradient wells during the first year. (d) After the first year, all monitoring wells must be sampled and the samples analyzed with the following frequencies: (1) Samples collected to establish ground-water quality must be obtained and analyzed for the parameters specified in paragraph (b)(2) of this section at least annually.	Section 2.1 and Appendix B, Section B2.2

Table 1-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement^a	Section Where Requirement is Addressed in Monitoring Plan
	<p>(2) Samples collected to indicate ground-water contamination must be obtained and analyzed for the parameters specified in paragraph (b)(3) of this section at least semi-annually.</p> <p>(e) Elevation of the ground-water surface at each monitoring well must be determined each time a sample is obtained.</p>	
Groundwater quality assessment program plan outline	<p>40 CFR 265.93, "Preparation, Evaluation, and Response":</p> <p>(a) Within one year after the effective date of these regulations, the owner or operator must prepare an outline of a ground-water quality assessment program. The outline must describe a more comprehensive ground-water monitoring program (than that described in §§265.91 and 265.92) capable of determining:</p> <p>(1) Whether hazardous waste or hazardous waste constituents have entered the ground water;</p> <p>(2) The rate and extent of migration of hazardous waste or hazardous waste constituents in the ground water; and</p> <p>(3) The concentrations of hazardous waste or hazardous waste constituents in the ground water.</p>	Chapter 4
Methods used to evaluate the collected data and responses	<p>40 CFR 265.93:</p> <p>(b) For each indicator parameter specified in §265.92(b)(3), the owner or operator must calculate the arithmetic mean and variance, based on at least four replicate measurements on each sample, for each well monitored in accordance with §265.92(d)(2), and compare these results with its initial background arithmetic mean. The comparison must consider individually each of the wells in the monitoring system, and must use the Student's t-test at the 0.01 level of significance (see appendix IV) to determine statistically significant increases (and decreases, in the case of pH) over initial background.</p> <p>(c)(2) If the comparison for downgradient wells made under paragraph (b) of this section show a significant increase (or pH decrease), the owner or operator must then immediately obtain additional ground-water samples from those downgradient wells where a significant difference was detected, split the samples in two, and obtain analyses of all additional samples to determine whether the significant difference was a result of laboratory error.</p> <p>(d)(1) If the analyses performed under paragraph (c)(2) of this section confirm the significant increase (or pH decrease), the owner or operator must provide written notice to the department within seven days of the date of such confirmation-that the facility may be affecting ground-water quality.</p> <p>(d)(2) Within 15 days after the notification under paragraph (d)(1) of this section, the owner or operator must develop a specific plan, based on the outline required under paragraph (a) of this section and certified by a qualified geologist or geotechnical engineer, for a ground-water quality assessment at the facility.</p>	Sections 3.1, 3.2, 3.3 and Appendix A

Table 1-2. Pertinent Interim Status Facility Groundwater Monitoring Requirements

Groundwater Monitoring Element	Pertinent Requirement^a	Section Where Requirement is Addressed in Monitoring Plan
Recordkeeping and reporting	<p>40 CFR 265.93:</p> <p>(c)(1) If the comparisons for the <i>upgradient</i> wells made under paragraph (b) of this section show a significant increase or (pH decrease), the owner or operator must submit this information in accordance with §265.94(a)(2)(ii).</p> <p>40 CFR 265.94, “Recordkeeping and Reporting”:</p> <p>(a)(1) Keep records of the analyses required in §265.92(c) and (d), the associated ground-water surface elevations required in §265.92(e), and the evaluation required in §265.93(b) throughout the active life of the facility.</p> <p>(a)(2) Report the following ground-water monitoring information to the department:</p> <p>(ii) Annually: Concentrations or values of the parameters listed in §265.92(b)(3) for each ground-water monitoring well, along with the required evaluations for these parameters under §265.93(b). The owner or operator must separately identify any significant differences from the initial background found in the upgradient wells, in accordance with §265.93(c)(1).</p> <p>(iii) No later than March 1 following each calendar year: Results of the evaluations of ground-water surface elevations under §265.93(f), and a description of the response to that evaluation, where applicable.</p>	Section 3.5 Appendix A, Section A2.6

Notes: Complete reference citations are provided in Chapter 5.

In accordance with WAC 173-303-400(3)(b), “Dangerous Waste Regulations,” “Interim Status Facility Standards,” for the purposes of applying the interim status standards of 40 CFR 265, “Interim Status Standards for Owners and Operations of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring,” the federal terms “Regional Administrator” means the “Department” and “Hazardous” means “Dangerous.”

In accordance with Section I.A of WA7890008967, *Hanford Facility Resource Conservation and Recovery Act (RCRA) Permit, Dangerous Waste Portion for the Treatment, Storage, and Disposal of Dangerous Waste* (Hanford Facility RCRA Permit), this unit will continue to be considered an interim status unit until it is incorporated into Part III, V, and/or VI of the Hanford Facility RCRA Permit, or until interim status is terminated. Therefore, groundwater monitoring continues under interim status requirements.

a. Regulatory requirements for interim status units, where no impact to groundwater has been identified, are found in WAC 173-303-400(3) and 40 CFR 265.90, “Applicability,” through 40 CFR 265.94, “Recordkeeping and Reporting,” which are applicable to this groundwater monitoring plan.

b. The parameters characterizing the suitability of the groundwater as a drinking water supply, as specified in 40 CFR 265, Appendix III, “EPA Interim Primary Drinking Water Standards,” are conducted only during the first year of monitoring of a unit in accordance with 40 CFR 265.92(c)(1), “Sampling and Analysis.” Because the first year of monitoring at this unit has been completed, Appendix III sampling is not applicable under this plan. New wells added to the monitoring network in this plan will be sampled for the constituents identified in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100* (modified to exclude polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, pesticides, and herbicides) for the first 1-year monitoring period to evaluate for any dangerous waste constituents or inadvertent contamination that occurred from the well drilling process (e.g., introduction of oil, grease, or other well construction materials used during drilling operations).

Sampling for site-specific and supporting constituents (Table 1-3) is not required under 40 CFR 265 but provides additional information supporting data interpretation. In addition to the parameters required by 40 CFR 265.92, site-specific constituents are monitored at WMA A-AX (Table 1-3). Chloroform is included for monitoring because it was detected in groundwater during the assessment at low-level concentrations (above the method detection limit but below the laboratory practical quantitation limit or required detection limit). Sampling will be performed to support charge balance calculation (alkalinity, anions [chloride, nitrate, sulfate] and metals [calcium, magnesium, potassium, and sodium]), identify corrosion in stainless steel well casing (chromium, iron, manganese, molybdenum, and nickel), and provide information on water properties at the time of sampling (dissolved oxygen, temperature, and turbidity). Nitrate and sulfate will be monitored to support identification of the cause of elevated specific conductance due to upgradient plumes (Sections 2.4 and 4.4.2 in SGW-60856).

Table 1-3. Additional Monitoring Objectives

Monitoring Objective/Rationale	Unit-Specific Constituents/Field Measurements*
Monitoring for potential contamination of groundwater from volatile organic compounds associated with WMA A-AX tanks	Chloroform
Charge balance calculations	<ul style="list-style-type: none"> • Alkalinity • Anions (chloride, nitrate, and sulfate) • Metals (calcium, magnesium, potassium, and sodium)
Monitoring for influence of upgradient plumes that can affect specific conductance measurements in network wells	Anions (nitrate and sulfate)
Monitoring for stainless steel well casing corrosion constituents	Metals (chromium, iron, manganese, molybdenum, and nickel)
Information on groundwater properties at the time of sampling	Field measurements (dissolved oxygen, temperature, and turbidity)

*Sampling for unit-specific constituents/field measurements is not required by WAC 173-303-400, "Dangerous Waste Regulations," "Interim Status Facility Standards," or 40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring."

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2 Groundwater Monitoring Program

This chapter describes the groundwater monitoring indicator evaluation program for WMA A-AX, consisting of parameters used as indicators of groundwater contamination, parameters establishing groundwater quality, site-specific and supporting constituents, sampling frequency, monitoring well network, and sampling and analysis protocols; and summarizes the differences between this plan and the previous groundwater monitoring plan (DOE/RL-2015-49).

2.1 Constituent List and Sampling Frequency

Table 2-1 presents the wells in the groundwater monitoring network, parameters and constituents to be analyzed, and the sampling frequency for monitoring of WMA A-AX.

Sampling for the parameters used as indicators of groundwater contamination (pH, specific conductance, TOC, and total organic halogen [TOX]) at WMA A-AX were not required during the groundwater quality assessment program, which commenced in 2005. Quadruplicate sampling for indicator parameters at WMA A-AX wells was initiated via a change notice issued in February 2020 (RCRA-CN-01_DOE/RL-2015-49_R0, *Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the Single-Shell Tank Waste Management Area A-AX*) to support the return of WMA A-AX to an indicator parameter monitoring program.

The quarterly quadruplicate sampling of the contamination indicator parameters that began under RCRA-CN-01_DOE/RL-2015-49_R0 will continue as needed under this plan until four quarters of quadruplicate sampling are completed. After the four quarterly sample events are completed, the contamination indicator parameters will be sampled semiannually, except for new wells which will require quarterly sampling and analysis for the first 1-year monitoring period.

Parameters establishing groundwater quality (chloride, iron, manganese, phenols, sodium, and sulfate) will be sampled and analyzed annually (40 CFR 265.92(b)(2) and (d)(1)), except for new wells which will require quarterly sampling and analysis for the first 1-year monitoring period. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 2-2.

Based on the findings from the first determination report, chloroform is included as a site-specific constituent and will be monitored semiannually.

Although not required to be collected under 40 CFR 265, supporting constituents will be sampled and analyzed semiannually to support interpretation of the required groundwater monitoring results and monitor the condition of the network wells². New wells (WMA_A-AX_PW-1 and WMA_A-AX_PW-2) will be sampled quarterly for supporting constituents for the first 1-year monitoring period, after which sampling will be performed semiannually. Supporting constituents are collected as follows:

- Charge balance calculation: alkalinity, anions (chloride, nitrate, and sulfate), and metals (calcium, magnesium, potassium, and sodium)
- Monitoring for influence of upgradient plumes that can affect specific conductance measurements in network wells: nitrate and sulfate
- Well casing corrosion constituents: chromium, iron, manganese, molybdenum, and nickel
- Field measurements to provide information on groundwater properties: dissolved oxygen, temperature, and turbidity

² Some supporting constituents (chloride, iron, manganese, sodium, and sulfate) that are needed to support interpretation of groundwater conditions are also required to be collected as groundwater quality parameters under 40 CFR 265.92(b)(2). The remaining supporting constituents are not required or subject to requirements under 40 CFR 265.

The analytical methods associated with the sampling constituents are provided in Table A-3 in Appendix A. Samples for metals that are analyzed by either method 6010 or 6020 in Table A-3 will be collected as both filtered and unfiltered samples.

Once installed, new wells (WMA_A-AX_PW-1 and WMA_A-AX_PW-2) will be sampled quarterly for the constituents identified in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, modified to exclude polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, pesticides, and herbicides (Table 2-3), for the first 1-year monitoring period to evaluate for any dangerous waste constituents or inadvertent contamination that occurred from the well drilling process (e.g., introduction of oil, grease, or other well construction materials used during drilling operations). The 1-year monitoring period at new wells will be performed concurrently with monitoring for indicator parameters, groundwater quality parameters, and supporting constituents; after which, Appendix 5 constituents will no longer be sampled. However, at the discretion of DOE, monitoring for constituents identified in Appendix 5 of Ecology Publication No. 97-407, as modified, (or a subset of the constituents) may be continued beyond 1 year if deemed necessary.

In the event that the well network is modified and an existing well³ is added to the network, the newly added existing well will also be sampled quarterly for the modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407 (Table 2-3) during the first 1-year monitoring period to evaluate for any dangerous waste constituents.

Consistent with the requirements of 40 CFR 265.92(e), "Sampling and Analysis," water-level measurements at each monitoring well will be determined each time that a sample is obtained.

³ "Existing well" refers to any well that is already installed and was not drilled specifically for this monitoring network.

Table 2-1. Monitoring Well Network and Sample Schedule for WMA A-AX

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters ^a										Supporting Constituents ^{c,d}			Site-Specific Constituents ^d	Table 2-3 Constituents ⁱ			
			Contamination Indicator Parameters ^b				Groundwater Quality Parameters ^c						Anions ^f	Field Measurements ^g	Metals ^h					
			Water Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron	Manganese	Phenols ^e	Sodium						Sulfate		
299-E24-20	Upgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E24-22	Upgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E24-33	Upgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E25-40	Downgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E25-41	Downgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E25-93	Downgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E25-94	Downgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
299-E25-237	Downgradient	Y	E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	A	A	A	A	A	A	S	S	S	S	S	N/A
WMA_A-AX_PW-1	Downgradient	Y	Q/E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q/A	Q/A	Q/A	Q/A	Q/A	Q/A	Q/S	Q/S	Q/S	Q/S	Q/S	Q
WMA_A-AX_PW-2	Downgradient	Y	Q/E	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q4/S4	Q/A	Q/A	Q/A	Q/A	Q/A	Q/A	Q/S	Q/S	Q/S	Q/S	Q/S	Q

a. Parameters are required by 40 CFR 265.92, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Sampling and Analysis."

b. The quarterly quadruplicate sampling of contamination indicator parameters that began under RCRA-CN-01_DOE/RL-2015-49_R0 will continue as needed under this plan until four quarterly sampling events are completed. After four quarterly sampling events are completed, the contamination indicator parameters will be sampled semiannually.

Table 2-1. Monitoring Well Network and Sample Schedule for WMA A-AX

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters ^a										Supporting Constituents ^{c,d}			Site-Specific Constituents ^d	Table 2-3 Constituents ⁱ		
			Contamination Indicator Parameters ^b			Groundwater Quality Parameters ^c							Anions ^f	Field Measurements ^g	Metals ^h				
			Water Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron	Manganese	Phenols ^e	Sodium				Sulfate	Alkalinity		
																		Chloroform	

c. Samples for metals that are analyzed by either method 6010 or 6020 in Table A-3 will be collected as both filtered and unfiltered samples.

d. Supporting constituents and site-specific constituents specified in Table 1-3 are used to support interpretation of the required groundwater monitoring results and provide a better understanding of the potential condition of the network wells. Some constituents (chloride, iron, manganese, sodium, and sulfate) are also collected as groundwater quality parameters, and are subject to collection requirements under 40 CFR 265.92. The remaining supporting constituents are not required, or subject to requirements, under 40 CFR 265. Supporting and site-specific constituents will be sampled semiannually.

e. The specific phenols to be analyzed as groundwater quality parameters are identified in Table 2-2.

f. Anions include chloride, nitrate, and sulfate.

g. Field measurements include dissolved oxygen, temperature, and turbidity.

h. Metals include calcium, magnesium, potassium, and sodium for groundwater chemistry and charge balance calculations and chromium, iron, manganese, molybdenum, and nickel for identification of well casing corrosion.

i. Sampling for a modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, (Table 2-3) will be performed during the first 1-year monitoring period at newly drilled wells. This sampling will apply to new wells WMA A-AX_PW-1 and WMA A-AX_PW-2. Sampling for these constituents may be discontinued after completion of the first year of monitoring. At the discretion of DOE, monitoring for constituents identified in Table 2-3 (or a subset of the constituents) may continue at newly installed wells beyond the first 1-year monitoring period if deemed necessary.

A = to be sampled annually

CFR = Code of Federal Regulations

DOE = U.S. Department of Energy

E = to be sampled at every event

N/A = not applicable

Q = to be sampled quarterly for the first year of monitoring

Q4 = to be sampled quarterly, with quadruplicate samples collected during each event

Table 2-1. Monitoring Well Network and Sample Schedule for WMA A-AX

Well Name	Purpose	WAC Compliant	RCRA-Required Parameters ^a										Supporting Constituents ^{c,d}				Site-Specific Constituents ^d	Table 2-3 Constituents ⁱ		
			Contamination Indicator Parameters ^b				Groundwater Quality Parameters ^c						Anions ^f	Field Measurements ^g	Metals ^h					
			Water Level	pH	Specific Conductance	Total Organic Carbon	Total Organic Halogen	Chloride	Iron	Manganese	Phenols ^e	Sodium	Sulfate	Alkalinity						
RCRA	=	Resource Conservation and Recovery Act of 1976																		
S	=	to be sampled semiannually																		
S4	=	to be sampled semiannually, with quadruplicate samples collected during each event																		
WAC	=	Washington Administrative Code																		
WMA	=	waste management area																		
Y	=	well is constructed as a resource protection well (WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells")																		

Table 2-2. Phenols Analyzed as Groundwater Quality Constituents

Constituent	CAS Number
2-Chlorophenol	95-57-8
2-Methylphenol (o-Cresol)	95-48-7
2-Nitrophenol (o-Nitrophenol)	88-75-5
2,3,4,6-Tetrachlorophenol	58-90-2
2,4-Dichlorophenol	120-83-2
2,4-Dimethylphenol (2,4-Xylenol)	105-67-9
2,4-Dinitrophenol	51-28-5
2,4,5-Trichlorophenol	95-95-4
2,4,6-Trichlorophenol	88-06-2
2,6-Dichlorophenol	87-65-0
3-Methylphenol (m-Cresol)	108-39-4*
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7
4-Methylphenol (p-Cresol)	106-44-5*
4,6-Dinitro-O-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1
Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	88-85-7
p-Nitrophenol (4-Nitrophenol)	100-02-7
Pentachlorophenol	87-86-5
Phenol	108-95-2

This table provides the specific phenols to be included for analysis as groundwater quality parameters under this monitoring plan

*Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9)

CAS = Chemical Abstracts Service

Table 2-3. Appendix 5 of Ecology Publication No. 97-407 Constituents (Modified)

Constituent	CAS Number	Constituent	CAS Number
Inorganics			
Antimony	7440-36-0	Mercury	7439-97-6
Arsenic	7440-38-2	Nickel	7440-02-0
Barium	7440-39-3	Selenium	7782-49-2
Beryllium	7440-41-7	Silver	7440-22-4
Cadmium	7440-43-9	Sulfide	18496-25-8
Chromium	7440-47-3	Thallium	7440-28-0
Cobalt	7440-48-4	Tin	7440-31-5
Copper	7440-50-8	Vanadium	7440-62-2
Cyanide (total and free)	57-12-5	Zinc	7440-66-6
Lead	7439-92-1	--	--
Volatile Organic Compounds			
1,1-Dichloroethane	75-34-3	Carbon tetrachloride	56-23-5
1,1-Dichloroethene (1,1-Dichloroethylene)	75-35-4	Chlorobenzene	108-90-7
1,1,1-Trichloroethane	71-55-6	Chloroethane	75-00-3
1,1,1,2-Tetrachloroethane	630-20-6	Chloroform	67-66-3
1,1,2-Trichloroethane	79-00-5	Chloroprene	126-99-8
1,1,2,2-Tetrachloroethane	79-34-5	Dibromochloromethane	124-48-1
1,2-Dibromo-3-chloropropane	96-12-8	p-Dichlorobenzene (1,4-Dichlorobenzene)	106-46-7
1,2-Dibromoethane	106-93-4	Dichlorodifluoromethane	75-71-8
1,2-Dichloroethane	107-06-2	Ethylbenzene	100-41-4
1,2-Dichloropropane	78-87-5	Ethyl methacrylate	97-63-2
trans-1,2-Dichloroethylene	156-60-5	Isobutanol (Isobutyl alcohol)	78-83-1
1,2,3-Trichloropropane	96-18-4	Methacrylonitrile	126-98-7
cis-1,3-Dichloropropene	10061-01-5	Methyl bromide (Bromomethane)	74-83-9
trans-1,3-Dichloropropene	10061-02-6	Methyl chloride (Chloromethane)	74-87-3
trans-1,4-Dichloro-2-butene	110-57-6	Methyl iodide (Iodomethane)	74-88-4
2-Butanone (Methyl ethyl ketone; MEK)	78-93-3	Methyl methacrylate	80-62-6
2-Propanone (Acetone)	67-64-1	Methylene bromide (Dibromomethane)	74-95-3
2-Hexanone (Methyl butyl ketone)	591-78-6	Methylene chloride	75-09-2
4-Methyl-2-pentanone (Methyl isobutyl ketone [MIBK])	108-10-1	Propionitrile (Ethyl cyanide)	107-12-0
Acetonitrile (Methyl cyanide)	75-05-8	Styrene	100-42-5
Acrolein	107-02-8	Tetrachloroethene	127-18-4
Acrylonitrile	107-13-1	Toluene	108-88-3

Table 2-3. Appendix 5 of Ecology Publication No. 97-407 Constituents (Modified)

Constituent	CAS Number	Constituent	CAS Number
Allyl chloride	107-05-1	Trichloroethylene (Trichloroethene [TCE])	79-01-6
Benzene	71-43-2	Trichlorofluoromethane	75-69-4
Bromodichloromethane	75-27-4	Vinyl acetate	108-05-4
Bromoform	75-25-2	Vinyl chloride (Chloroethene)	75-01-4
Carbon disulfide	75-15-0	Xylenes (total)	1330-20-7
Semivolatile Organic Compounds			
1-Naphthylamine	134-32-7	Dibenzofuran	132-64-9
1,2-Dichlorobenzene (o-Dichlorobenzene)	95-50-1	m-Dichlorobenzene (1,3-Dichlorobenzene)	541-73-1
1,2,4-Trichlorobenzene	120-82-1	Diethyl phthalate	84-66-2
1,2,4,5-Tetrachlorobenzene	95-94-3	O,O-Diethyl O-2-pyrazinyl phosphorothioate	297-97-2
1,4-Dioxane	123-91-1	p-(Dimethylamino)azobenzene	60-11-7
1,4-Naphthoquinone	130-15-4	alpha, alpha-Dimethylphenethylamine	122-09-8
2-Acetylaminofluorene	53-96-3	Dimethyl phthalate	131-11-3
2-Chloronaphthalene	91-58-7	Di-n-butyl phthalate	84-74-2
2-Chlorophenol	95-57-8	m-Dinitrobenzene	99-65-0
2-Methylphenol (o-Cresol)	95-48-7	Di-n-octylphthalate	117-84-0
2-Methylnaphthalene	91-57-6	Diphenylamine	122-39-4
2-Naphthylamine	91-59-8	Ethyl methanesulfonate	62-50-0
2-Nitrophenol (o-Nitrophenol)	88-75-5	Fluoranthene	206-44-0
2-Picoline	109-06-8	9H-Fluorene (Fluorene)	86-73-7
2,3,4,6-Tetrachlorophenol	58-90-2	Hexachlorobenzene	118-74-1
2,4-Dichlorophenol	120-83-2	Hexachlorobutadiene	87-68-3
2,4-Dimethylphenol	105-67-9	Hexachlorocyclopentadiene	77-47-4
2,4-Dinitrophenol	51-28-5	Hexachloroethane	67-72-1
2,4-Dinitrotoluene	121-14-2	Hexachlorophene	70-30-4
2,4,5-Trichlorophenol	95-95-4	Hexachloropropene	1888-71-7
2,4,6-Trichlorophenol	88-06-2	Indeno(1,2,3-cd)pyrene	193-39-5
2,6-Dichlorophenol	87-65-0	Isophorone	78-59-1
2,6-Dinitrotoluene	606-20-2	Isosafrole	120-58-1
3-Methylcholanthrene	56-49-5	Methapyrilene	91-80-5
3-Methylphenol (m-Cresol)	108-39-4	Methyl methanesulfonate	66-27-3
4-Methylphenol (p-Cresol)	106-44-5	Naphthalene	91-20-3
3,3'-Dichlorobenzidine	91-94-1	Nitrobenzene	98-95-3
3,3'-Dimethylbenzidine	119-93-7	o-Nitroaniline (2-Nitroaniline)	88-74-4
4-Aminobiphenyl	92-67-1	m-Nitroaniline (3-Nitroaniline)	99-09-2
4-Bromophenyl phenyl ether	101-55-3	p-Nitroaniline (4-Nitroaniline)	100-01-6

Table 2-3. Appendix 5 of Ecology Publication No. 97-407 Constituents (Modified)

Constituent	CAS Number	Constituent	CAS Number
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	59-50-7	p-Nitrophenol (4-Nitrophenol)	100-02-7
4-Chlorophenyl phenyl ether	7005-72-3	n-Nitrosodi-n-butylamine	924-16-3
4-Nitroquinoline 1-oxide	56-57-5	n-Nitrosodiethylamine	55-18-5
4,6-Dinitro-o-cresol (4,6-Dinitro-2-methyl phenol)	534-52-1	n-Nitrosodimethylamine	62-75-9
5-Nitro-o-toluidine	99-55-8	n-Nitrosodiphenylamine	86-30-6
7,12-Dimethylbenz[a]anthracene	57-97-6	n-Nitroso-di-n-dipropylamine (n-Nitrosodipropylamine; Di-n-propylnitrosamine)	621-64-7
Acenaphthene	83-32-9	n-Nitrosomethylethylamine	10595-95-6
Acenaphthylene	208-96-8	n-Nitrosomorpholine	59-89-2
Acetophenone	98-86-2	n-Nitrosopiperidine	100-75-4
Aniline	62-53-3	n-Nitrosopyrrolidine	930-55-2
Anthracene	120-12-7	Pentachlorobenzene	608-93-5
Aramite	140-57-8	Pentachloroethane	76-01-7
Benz[a]anthracene (Benzo[a]anthracene)	56-55-3	Pentachloronitrobenzene	82-68-8
Benz[e]acephenanthrylene (Benzo[b]fluoranthene)	205-99-2	Pentachlorophenol	87-86-5
Benzo[k]fluoranthene	207-08-9	Phenacetin	62-44-2
Benzo[ghi]perylene	191-24-2	Phenanthrene	85-01-8
Benzo[a]pyrene	50-32-8	Phenol	108-95-2
Benzyl alcohol	100-51-6	p-Phenylenediamine	106-50-3
Bis(2-chloroethoxy)methane	111-91-1	Pyrene	129-00-0
Bis(2-chloroethyl)ether	111-44-4	Pyridine	110-86-1
Bis(2-chloro-1-methylethyl) ether (2,2'-Oxybis(1-chloropropane))	108-60-1	Safrole	94-59-7
Bis(2-ethylhexyl)phthalate	117-81-7	Tetraethyl dithiopyrophosphate	3689-24-5
Butylbenzylphthalate	85-68-7	o-Toluidine	95-53-4
p-Chloroaniline (4-Chloroaniline)	106-47-8	O,O,O-Triethyl phosphorothioate	126-68-1
Chrysene	218-01-9	sym-Trinitrobenzene	99-35-4
Dibenz[a,h]anthracene	53-70-3	--	--

Note: This table identifies the dangerous waste constituents listed in Appendix 5 of Ecology Publication No. 97-407, *Chemical Test Methods For Designating Dangerous Waste WAC 173-303-090 & -100*, without polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, pesticides, and herbicides. This appendix is incorporated at WAC 173-303-110(3)(c) and (7), "Dangerous Waste Regulations," "Sampling, Testing Methods and Analyses."

CAS = Chemical Abstracts Service

2.1.1 Sample Schedule Impacts from Well Maintenance and Sampling Logistics

Well maintenance (e.g., pump repairs, periodic well cleaning, and redevelopment) and sampling logistics resulting from multiple factors including environmental (e.g., inclement weather) and access restrictions (e.g., heightened fire danger, area access restriction due to work by other Hanford Site contractors such as in the tank farms) sometimes delay scheduled sampling events. Sampling events are scheduled by month. The Field Work Supervisor (FWS) determines the sampling schedule for a well within a given month. If a well cannot be sampled at the times determined by the FWS, then the FWS and Sample Management and Reporting group, along with the project scientist, consult to determine how best to recover or reschedule the sampling event as close to the original sampling date as possible. If it is observed during the presampling walkdown that one or more network wells cannot be sampled, then sampling of the well network will not begin and management will be notified. Depending on the situation, the network sampling is rescheduled as soon as is feasible to meet the schedule set forth in this plan. In some cases, it may not be obvious that sampling cannot be performed until a well is accessed (e.g., an issue with a pump).

Missed sampling events that are not rescheduled within the same month are given top priority when scheduling sampling for the following month. In the event that a sampling delay has occurred and the representativeness of the samples is in question, DOE and Ecology may agree to resampling wells. DOE will provide informal notification to Ecology if sampling of the network is expected to be delayed for longer than 4 weeks. Ecology may provide input in a timely fashion to DOE on how to proceed. Missed or cancelled sampling events are reported to DOE and are documented in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2019-65, *Hanford Site RCRA Groundwater Monitoring Report for 2019*).

2.1.2 Well Biofouling and Total Organic Carbon Results

Biofouling of wells can result in collection of nonrepresentative groundwater samples and produce nonrepresentative analytical results for TOC. In Hanford Site wells, biofouling is often associated with iron-oxidizing and manganese-oxidizing bacteria. The bacterial growths are physically manifested as slime or as filamentous or flocculent accumulations. The accumulations frequently occur in the screened interval and exhibit discrete coloration (e.g., rusty orange in the case of iron-oxidizing bacteria or black in the case of manganese-oxidizing bacteria).

TOC is a nonspecific analysis that is used as an indicator of the presence of organic compounds in groundwater. TOC represents organic compounds in the sample; including dissolved organic compounds as well as suspended organic particles that may be present in an unfiltered sample. Suspended organic materials in groundwater samples can include microbial biomass associated with well biofouling. TOC is used in detection monitoring as an indicator of the possible presence of regulated organic compounds, but the TOC measurement is nonspecific. Furthermore, the TOC measurement is subject to positive interference if suspended organic material (e.g., microbial biomass) or dissolved naturally-occurring organic compounds (e.g., humic and fulvic acids) are present in the sample.

If elevated concentrations of TOC are measured within a well (particularly, if a TOC concentration above the critical mean is encountered), then well maintenance activities will be notified. Well maintenance activities are designed to reduce the impact of biomass transfer from the well and generation of a resultant high TOC value. Well maintenance may include cleaning/rehabilitation of the well to ensure that the groundwater samples collected are representative of ambient groundwater conditions and not the result of sampling of biomass material present within the well. A down-hole camera survey and well cleaning may be scheduled following receipt of an elevated TOC result where biofouling of the well is suspected.

Subsequent to well maintenance activities, a well having an exceedance of the critical mean for TOC will be sampled for confirmational laboratory split samples as required under 40 CFR 265.93(c)(2).

2.1.3 Well Casing Corrosion

Groundwater chemistry is routinely reviewed and evaluated. If the groundwater chemistry data for a well demonstrate a consistent upward trend over time for stainless steel corrosion constituents (chromium, iron, manganese, molybdenum, and nickel) in proportionate concentrations as found in stainless steel, it may be an indicator of corrosion. These data are used to provide a better understanding of the potential condition of the network wells and are used for information only.

2.2 Monitoring Well Network

The groundwater well network identified for interim status monitoring of WMA A-AX is the same as that proposed for final status monitoring in Section 9.3 in SGW-60586 and consists of three upgradient wells (299-E24-20, 299-E24-22, and 299-E24-33) and seven downgradient wells (existing wells 299-E25-40, 299-E25-41, 299-E25-93, 299-E25-94, and 299-E25-237, and proposed wells WMA_A-AX_PW-1 and WMA_A-AX_PW-2) (Table 2-1). The network wells were selected through the methodology presented in Chapters 5 through 7 of SGW-60586, based on known groundwater conditions.

The well network in the previous groundwater monitoring plan included downgradient well 299-E25-2. This well is not included in the final status network proposed in SGW-60586 because it is not located in the particle flow path and is not compliant with the construction standards in WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells” (Section 7.4 in SGW-60586). Well WMA_A-AX_PW-2 was proposed to replace well 299-E25-2; it is located closer to the WMA in an area better suited to detect releases (Section 7.4 in SGW-60586).

The groundwater flow direction at WMA A-AX is to the south-southeast (Section 9.3 in SGW-60586). Specific details regarding the selection of each of the well locations is presented in Sections 9.3.1 through 9.3.10 of SGW-60586. Figure 2-1 presents the groundwater monitoring network to be used in this plan. Information on the wells comprising the network is summarized in Table 2-4.

If a well is within approximately 2 years of going sample dry, a replacement well is proposed; such wells that are proposed for installation at the Hanford Site are negotiated annually by Ecology, DOE, and EPA under Tri-Party Agreement Milestone M-24-00 (Ecology et al., 1989).

Construction details and pertinent information for the wells are provided in Appendix C of this groundwater monitoring plan.

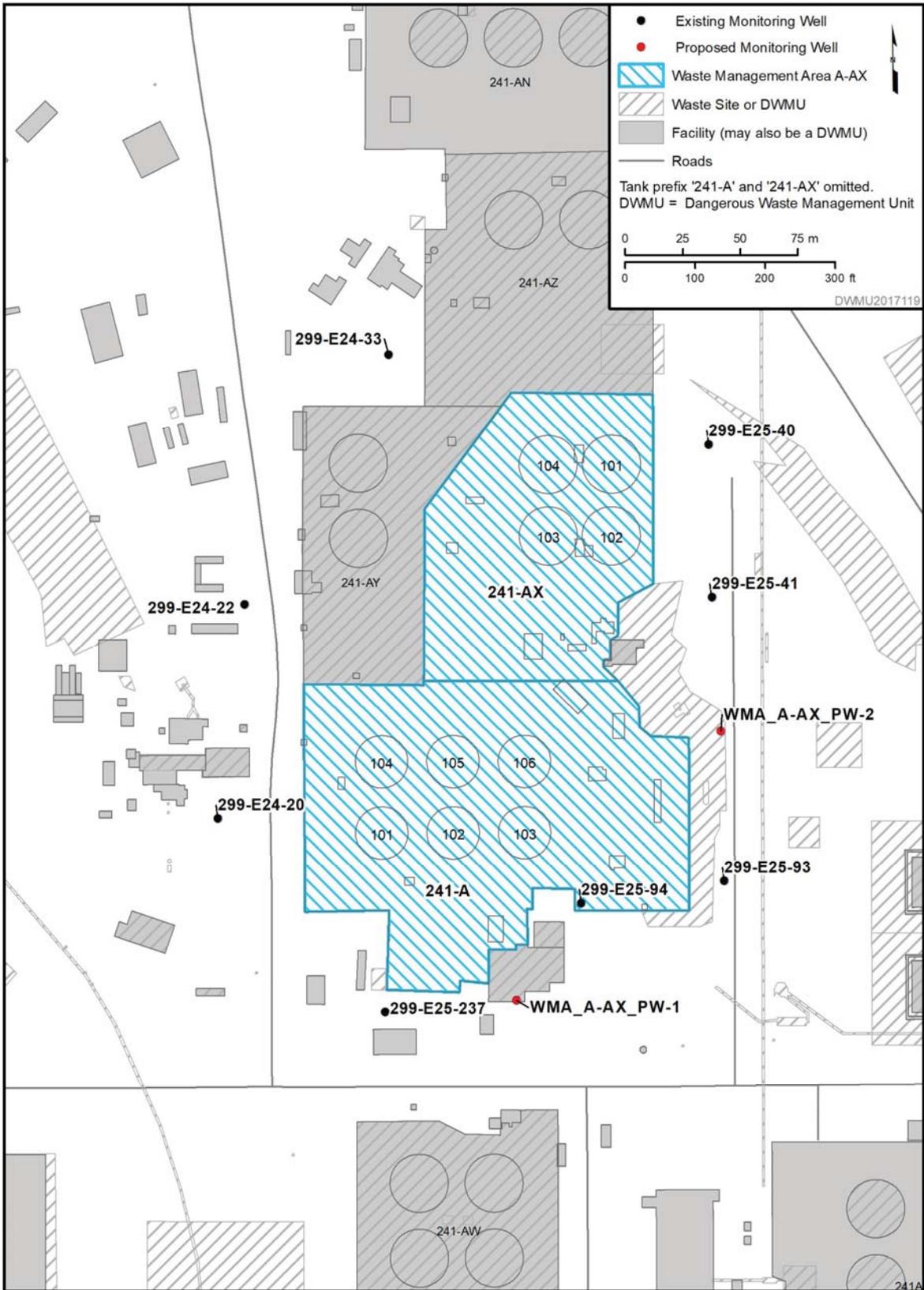


Figure 2-1. WMA A-AX Monitoring Well Network

Table 2-4. Attributes for Wells in the WMA A-AX Groundwater Monitoring Network

Well Name	Completion Date	Easting ^a (m)	Northing ^a (m)	Top of Casing Elevation (m [ft]) (NAVD88)	Water Table Elevation (m [ft]) (amsl)	Water Depth (m [ft] bgs)	Depth of Water in Screen (m [ft])	Water-Level Date
299-E24-20	3/14/1991	575251.10	136049.40	211.16 (692.77)	121.63 (399.04)	88.6 (290.5)	2.8 (9.0)	9/18/2019
299-E24-22	7/17/2003	575262.68	136142.82	210.29 (689.91)	121.62 (399.01)	88.0 (288.6)	10.0 (32.7)	9/20/2019
299-E24-33	8/27/2004	575325.40	136251.45	206.80 (678.48)	121.60 (398.94)	84.4 (277.0)	10.1 (33.1)	9/30/2019
299-E25-40	9/18/1989	575464.68	136212.32	204.00 (669.28)	121.59 (398.93)	81.5 (267.4)	1.7 (5.6)	9/20/2019
299-E25-41	9/22/1989	575466.06	136145.93	205.69 (674.83)	121.61 (398.98)	83.1 (272.2)	1.1 (3.6)	9/20/2019
299-E25-93	8/14/2003	575471.51	136022.09	208.04 (682.56)	121.61 (398.98)	85.7 (281.0)	9.8 (32.2)	9/30/2019
299-E25-94	9/27/2004	575409.17	136012.43	211.31 (693.28)	121.66 (399.15)	89.6 (294.1)	11.0 (36.0)	9/19/2019
299-E25-237	1/19/2015	575323.84	135965.27	212.63 (697.59)	121.54 (398.75)	90.3 (296.4)	9.0 (29.6)	9/19/2019
WMA_A-AX_PW-1	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
WMA_A-AX_PW-2	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Reference: NAVD88, *North American Vertical Datum of 1988*.

^aCoordinates are in Washington State Plane (south zone), NAD83, *North American Datum of 1983*; 1991 adjustment.

amsl = above mean sea level

bgs = below ground surface

TBD = to be determined. Information will be obtained after well construction.

2.3 Differences Between This Plan and Previous Plan

Table 2-5 identifies the main differences between this plan and the previous groundwater monitoring plan (DOE/RL-2015-49).

Table 2-5. Main Differences Between this Monitoring Plan and Previous Monitoring Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
Constituents	40 CFR 265 indicator parameters and groundwater quality parameters: -pH and specific conductance included as field parameters -Indicator parameters TOC and TOX added in February 2020 under RCRA-CN-01_DOE/RL-2015-49_R0 -Groundwater quality parameters iron, manganese, sodium, and sulfate were monitored as supporting constituents; phenols monitored as assessment constituents.	40 CFR 265 indicator parameters and groundwater quality parameters: included	Collection of indicator parameters and groundwater quality parameters is specified as required by 40 CFR 265.92(b)(2) and (3).
	40 CFR 265 Appendix III parameters: included for well added to the network (299-E25-237)	40 CFR 265 Appendix III parameters: not applicable	40 CFR 265, Appendix III has been completed.
	Modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407: not applicable	Modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407: included for wells added to network (WMA_A-AX_PW-1 and WMA_A-AX_PW-2)	Sampling of the modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407 will evaluate for the presence of dangerous waste constituents or inadvertent contamination from the well drilling process.
	Supporting constituents: alkalinity, anions (chloride, nitrate, and sulfate), metals (calcium, chromium, iron, manganese, magnesium, molybdenum, nickel, potassium, and sodium)	Supporting constituents: alkalinity, anions (chloride, nitrate, and sulfate), and metals (calcium, chromium, iron, manganese, magnesium, molybdenum, nickel, potassium, and sodium) Site-specific constituent: chloroform	Chloroform was identified for monitoring in the first determination report (DOE/RL-2019-21). Molybdenum added because it is a component of certain types of stainless steel.

Table 2-5. Main Differences Between this Monitoring Plan and Previous Monitoring Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
	Field parameters: pH, specific conductance, temperature, turbidity, and water level	Field measurements: dissolved oxygen, temperature, turbidity, and water level	pH and specific conductance are included as indicator parameters. Dissolved oxygen is added as a standard field measurement amongst the RCRA units.
	Assessment constituents: Constituents identified in Appendix 5 of Ecology Publication No. 97-407	Assessment constituents: not applicable	Sampling for assessment constituents was completed under the previous plan.
Sampling frequency	40 CFR 265 indicator parameters and groundwater quality parameters: quarterly	40 CFR 265 indicator parameters: -Existing wells: quarterly until four quarters of quadruplicate samples are completed, semiannually thereafter - New wells added to the network: quarterly during the first 1-year monitoring period, semiannually thereafter (WMA_A-AX_PW-1 and WMA_A-AX_PW-2) 40 CFR 265 groundwater quality parameters: - Existing wells: quarterly until four quarters of quadruplicate samples of indicator parameters are completed, semiannually thereafter - New wells added to the network: quarterly during the first 1-year monitoring period, annually thereafter (WMA_A-AX_PW-1 and WMA_A-AX_PW-2)	Sampling frequency changed to that prescribed in 40 CFR 265.92(d), with additional sampling for indicator parameters to complete four quarters of quadruplicate samples (initiated under RCRA-CN-01_DOE/RL-2015-49_R0).
	40 CFR 265 Appendix III parameters: quarterly for 1 year at new well (299-E25-237)	40 CFR 265 Appendix III parameters: not applicable	40 CFR 265 Appendix III parameter sampling has been completed.
	Modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407: not applicable	Modified list of constituents identified in Appendix 5 of Ecology Publication No. 97-407: quarterly for 1 year at new wells (WMA_A-AX_PW-1 and WMA_A-AX_PW-2)	Quarterly monitoring for constituents identified in Appendix 5 of Ecology Publication No. 97-407 for 1 year will provide sufficient samples to evaluate groundwater conditions at wells added to the network.

Table 2-5. Main Differences Between this Monitoring Plan and Previous Monitoring Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
	Supporting constituents: quarterly	Site-specific and supporting constituents: - Semiannually at existing wells - Quarterly for 1 year then semiannually thereafter at new wells added to the network (WMA_A-AX_PW-1 and WMA_A-AX_PW-2)	Supporting constituents were sampled quarterly to align with the frequency of the groundwater quality assessment sampling. Site-specific and supporting constituents in this plan are sampled at the same frequency as the indicator parameters to support interpretation of the required sampling results.
	Field parameters: quarterly	Field measurements: - Semiannually at existing wells - Quarterly for 1 year then semiannually thereafter at new wells added to the network (WMA_A-AX_PW-1 and WMA_A-AX_PW-2)	Field measurements are collected at each sample event.
	Assessment constituents: quarterly	Assessment constituents: not included	Sampling for assessment constituents was completed under the previous plan.
Well network	Upgradient: 299 E24 20 299-E24-22 299-E24-33	Upgradient: Same	The well network for WMA A-AX is revised to match that determined in SGW-60586 for future final status monitoring under Revision 9 of the Hanford Facility Sitewide Permit. Well 299-E25-2 is not included in that network because it is not in the particle flow path and is not compliant with the construction standards in WAC 173-160. Proposed well WMA_A-AX_PW-2 is included to replace well 299-E25-2. The new monitoring wells (e.g., WMA_A-AX_PW-1) will allow for detection of contamination, should there be a release from WMA A-AX under the range of operating conditions evaluated, and considering potential groundwater flow changes.
	Downgradient: 299-E25-2 299-E25-40 299 E25 41 299-E25-93 299-E25-94 299-E25-237	Downgradient: 299-E25-40 299 E25 41 299-E25-93 299-E25-94 299-E25-237 WMA_A-AX_PW-1 WMA_A-AX_PW-2	

Table 2-5. Main Differences Between this Monitoring Plan and Previous Monitoring Plan

Type of Change	Previous Plan*	Current Plan	Justification Summary
Groundwater flow direction	Southeast	South-southeast	A south-southeast flow direction was used in SGW-60586 to evaluate the ability of the well network to detect contamination from the WMA.
Type of groundwater monitoring program	Groundwater quality assessment	Indicator parameter monitoring	The groundwater quality assessment first determination report did not find that dangerous waste from WMA A-AX had contaminated the groundwater. Therefore, the WMA returned to indicator parameter monitoring program.

Note: Complete reference citations are provided in Chapter 5.

*DOE/RL-2015-49, *Interim Status Groundwater Quality Assessment Plan for the Single-Shell Tank Waste Management Area A-AX*, as modified by RCRA-CN-01_DOE/RL-2015-49_R0, *Interim Status Change Number 1: Interim Status Groundwater Monitoring Plan for the Single-Shell Tank Waste Management Area A-AX*

TOC = total organic carbon

TOX = total organic halogens

WMA = waste management area

2.4 Sampling and Analysis Protocol

The groundwater protection regulations of WAC 173-303-400 dictate the groundwater sampling and analysis requirements applicable to interim status DWMUs. The QAPjP outlining the project management structure, data generation and acquisition, analytical procedures, and quality control is provided in Appendix A. Appendix B provides the sampling protocols (e.g., sampling methods, sample handling and custody, management of waste, and health and safety considerations).

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3 Data Evaluation and Reporting

This chapter discusses the evaluation and interpretation of data.

3.1 Data Review

The data review and verification tasks are discussed in the QAPjP (Appendix A).

3.2 Statistical Evaluation

The goal of the groundwater monitoring indicator evaluation program is to determine if WMA A-AX operations have affected groundwater quality beneath the unit, which is determined based on the results of specified statistical tests. Under this plan, sampling activities and statistical evaluation methods are based on 40 CFR 265, Subpart F (incorporated by reference into WAC 173-303-400). These interim status regulations require the use of a statistical method that compares mean concentrations of the four general groundwater contamination indicator parameters (pH, specific conductance, TOC, and TOX) to background levels (critical means) to test for potential impact to groundwater. Each time a monitoring well is sampled, four replicate samples for TOC and TOX are collected, and four replicate field measurements are made for pH and specific conductance.

After the critical mean values are established, the basic procedure for statistical comparisons is as follows. Semiannually, monitoring data from downgradient wells are compared to the upgradient (background) results for each of the four indicator parameters. The arithmetic mean and variance must be calculated based on at least four replicate measurements on each sample, for each well monitored, and then compared with the background arithmetic mean obtained (40 CFR 265.92(c)(2)) and updated as discussed in Chapter 5 of EPA 530/R-09-007, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities Unified Guidance*. The comparison must consider each of the individual wells in the monitoring system and must use the Student's t-test at the 0.01 level of significance to determine statistically significant increases (increases or decreases, in the case of pH) over background (40 CFR 265.93(b) and Appendix IV to 40 CFR 265). Implementation of the statistical test method at the Hanford Site, including at WMA A-AX, is generally consistent with EPA 530/R-09-007. The background statistical analysis is updated annually to establish comparative values for indicator parameters. A rolling mean is used because of changing upgradient concentrations and groundwater flow conditions.

If a downgradient well comparison shows a significant increase (or pH increase or decrease), then the well is resampled. Split samples are sent to different laboratories to determine if the exceedance of the comparison value was the result of laboratory error.

If the exceedance of the statistical comparison value is confirmed by resampling, then written notifications are made as detailed in Section 3.5 and in accordance with 40 CFR 265.93(d)(1).

The critical mean values to be used when WMA A-AX returns to indicator parameter monitoring will comprise the most recently calculated values for the unit. Sampling for indicator parameters at WMA A-AX and critical mean calculations were not required during the groundwater quality assessment program, which commenced in 2005. However, samples for pH, specific conductance, and TOC were collected at WMA A-AX wells during the assessment and sufficient data are available to calculate critical mean values for comparison. Sampling for indicator parameter at WMA A-AX wells was initiated via a change notice issued in February 2020 (RCRA-CN-01_DOE/RL-2015-49_R0) to support return of the WMA to indicator parameter monitoring and collect sufficient samples to calculate critical means.

3.3 Interpretation

Data are used to interpret groundwater conditions at WMA A-AX. Interpretive techniques may include the following:

- **Hydrographs:** Graph water levels versus time to determine decreases, increases, seasonal, or manmade fluctuations in groundwater levels.
- **Water table maps:** Use water table elevations from multiple wells to construct contour maps and to estimate flow directions. Groundwater flow is assumed to be perpendicular to the potential lines on the maps.
- **Trend plots:** Graph concentrations of constituents versus time to determine increases, decreases, and fluctuations. May be used in tandem with hydrographs and/or water table maps to determine if concentrations relate to changes in water level or groundwater flow directions.
- **Plume maps:** Map distributions of chemical constituent concentrations in the aquifer to determine the extent of contamination. Changes in plume distribution over time assist in determining plume movement and direction of groundwater flow.
- **Contaminant ratios:** Illustrate the relative abundances of contaminants from previously characterized Hanford Site-related processes and sources. Comparison of these ratios in groundwater can sometimes be used to distinguish among different sources of contamination (e.g., a specific process and its associated facility). Ratios may provide evidence of continuing source contamination, thereby linking contamination with a specific facility under monitoring. Evaluation of contaminant ratios in concentration trends may be used to demonstrate when facility-specific contamination no longer affects underlying groundwater.

3.4 Annual Determination of Monitoring Network

Groundwater monitoring requirements include an annual evaluation of the network to determine if it remains adequate to monitor the facility's impact on the quality of the groundwater in the uppermost aquifer underlying the facility (40 CFR 265.93(f)). The network must include at least one upgradient and at least three downgradient wells in the uppermost aquifer (40 CFR 265.91(a)(1) and (2)).

The groundwater monitoring network will continue to be re-evaluated to ensure that it is adequate to monitor any changing hydrogeologic conditions beneath the unit. If flow changes are observed, the WMA A-AX contaminant migration conceptual model and geochemical trends will be reevaluated to determine the adequacy of the network and any necessary modifications required for the network. If a change in the groundwater flow direction occurs and the monitoring network is no longer aligned to the flow direction, then the monitoring network will be modified and a revised monitoring plan will be prepared.

Water-level measurements will continue to be collected during each sampling event. An additional and more comprehensive set of water-level measurements is made annually for selected wells on the Hanford Site; interpretation of these data may be found in the annual Hanford Site groundwater monitoring reports (e.g., DOE/RL-2019-65).

3.5 Reporting and Notification

Groundwater monitoring and evaluation of groundwater surface elevation results are reported annually in accordance with the requirements of 40 CFR 265.94(a)(2). Reporting will be made in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2019-65) by March 1.

If an upgradient well comparison shows a significant increase (or pH decrease) relative to the statistical comparison value, that information is also reported (40 CFR 265.93(c)(1)) in the annual Hanford Site RCRA groundwater monitoring report (e.g., DOE/RL-2019-65) by March 1.

If the exceedance of the statistical comparison value is confirmed, written notice is then provided to Ecology within 7 days (40 CFR 265.93(d)(1)) stating that the facility may be affecting groundwater quality. Within 15 days after the notification, a groundwater quality assessment program must be developed and placed in the facility operating record (40 CFR 265.93(d)(2)). This plan must be submitted to Ecology (WAC 173-303-400(3)(c)(v)(D)).

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4 Outline for Groundwater Quality Assessment Plan

If a groundwater contamination indicator parameter at a downgradient well significantly exceeds the background value (or if pH significantly decreases) and is confirmed by verification sampling, a groundwater quality assessment plan will be prepared and submitted to Ecology, and the facility monitoring will be elevated to assessment monitoring status. The assessment program must be capable of determining whether dangerous waste or dangerous waste constituents from the facility have entered the groundwater, the rate and extent of migration, and the concentration. This chapter presents a revision of the groundwater quality assessment monitoring plan outline prepared during the first year after the effective date of the regulations, as required by 40 CFR 265.93(a). Information on the facility description, operational history, waste characteristics, geology and hydrogeology, groundwater monitoring history, and contaminant migration conceptual model are provided in the EER for groundwater monitoring associated with this unit, which will be referenced in the groundwater quality assessment monitoring plan. An outline for the assessment plan is presented in Table 4-1. Changes may be made to this outline as applicable. The groundwater quality assessment program may include the following elements:

- Description of the investigative approach for making first determination to decide if dangerous waste or dangerous waste constituents from the facility have entered the groundwater or if the exceedance was caused by other sources (false positive rationale)
- Description of the approach to characterize rate and extent of contaminant migration
- Number, locations, and depths of wells in the monitoring network
- Sampling and analytical methods used
- Data evaluation methods
- An implementation schedule

The results of assessment determinations will be made as soon as technically feasible and a report of the findings will be sent to Ecology. The results of the groundwater quality assessment program will then be reported annually as required by 40 CFR 265.94(b).

Table 4-1. Suggested Groundwater Quality Assessment Plan Outline

Introduction
Regulatory Basis
Monitoring Objectives
Groundwater Monitoring
Constituent List and Sampling Frequency
Well Network
Sampling and Analysis Protocol
Data Evaluation and Reporting
Data Review
Data Evaluation
Interpretation
Annual Determination of Monitoring Network
Reporting, Recordkeeping, and Notification
Implementation Schedule
References
Appendix A – Quality Assurance Project Plan
Appendix B – Sampling Protocol
Appendix C – As-Built Drawings of Wells in Well Network

Notes: Information on the facility description, operational history, waste characteristics, geology and hydrogeology, groundwater monitoring history, and contaminant migration conceptual model are provided in the engineering evaluation report for groundwater monitoring associated with this unit, which will be referenced in the groundwater quality assessment monitoring plan.

Changes may be made to this outline, as applicable.

5 References

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Appendix A
Quality Assurance Project Plan

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Terms

DOE	U.S. Department of Energy
DQI	data quality indicator
DUP	duplicate (laboratory)
DWMU	dangerous waste management unit
EB	equipment blank
ECO	Environmental Compliance Officer
EPA	U.S. Environmental Protection Agency
FSO	Field Sample Operations
FTB	full trip blank
FWS	Field Work Supervisor
FXR	field transfer blank
HEIS	Hanford Environmental Information System
LCS	laboratory control sample
MB	method blank
MS	matrix spike
MSD	matrix spike duplicate
QA	quality assurance
QAPjP	quality assurance project plan
QC	quality control
SMR	Sample Management and Reporting
SPLIT	field split
SUR	surrogate
VOC	volatile organic compound

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A1 Introduction

A quality assurance project plan (QAPjP) establishes the quality requirements for environmental data collection. This QAPjP includes planning, implementation, and assessment of sampling tasks, field measurements, laboratory analysis, and data review. This chapter describes the applicable environmental data collection quality assurance (QA) elements for this groundwater monitoring plan. This QAPjP is intended to supplement the contractor's environmental QA program plan.

This QAPjP is divided into the following four chapters that describe the quality requirements and controls applicable to the dangerous waste management unit (DWMU) groundwater monitoring activities:

- Chapter A2, Project Management
- Chapter A3, Data Generation and Acquisition
- Chapter A4, Data Review and Usability
- Chapter A5, References

A2 Project Management

This chapter addresses the management approaches planned, project goals, and planned documentation.

A2.1 Project/Task Organization

Project organization (regarding groundwater monitoring) is described in the following sections and illustrated in Figure A-1. Titles used in the project organization are for the purposes of discussing the role of the individual in the performance of the work scope. Individuals with different titles but similar/equivalent positions may fulfill these roles.

A2.1.1 U.S. Department of Energy Manager

Hanford Site operation is the responsibility of the U. S. Department of Energy (DOE). The DOE Manager is responsible for authorizing the contractor to perform activities at the Hanford Site under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*; *Resource Conservation and Recovery Act of 1976*; *Atomic Energy Act of 1954*; and *Hanford Federal Facility Agreement and Consent Order* (Ecology et al., 1989).

A2.1.2 U.S. Department of Energy Project Lead

The DOE Project Lead is responsible for providing day-to-day oversight of the contractor's performance of the work scope, working with the contractor to identify and work through issues, and providing technical input to DOE management.

A2.1.3 U.S. Department of Energy Primary Contractor Management for Groundwater Science

The DOE Primary Contractor Management for Groundwater Science provides oversight and coordinates with DOE in support of sampling and reporting activities. The DOE Primary Contractor Management for Groundwater Science also provides support to the Project Delivery Manager for Groundwater Science to ensure that work is performed safely and cost effectively.

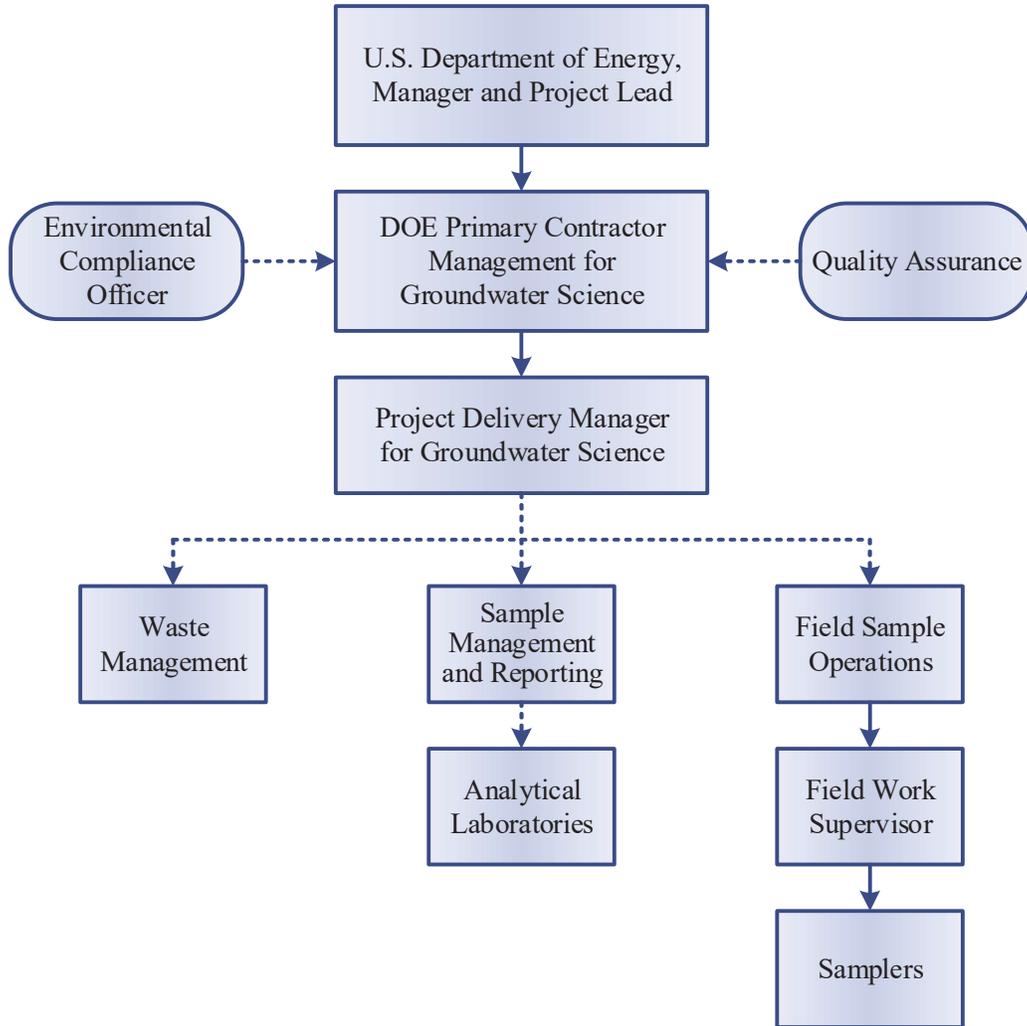


Figure A-1. Project Organization

A2.1.4 Project Delivery Manager for Groundwater Science

The Project Delivery Manager for Groundwater Science is responsible for direct management of activities performed to meet DWMU groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science coordinates with, and reports to, DOE and DOE Primary Contractor Management for Groundwater Science regarding DWMU groundwater monitoring requirements. The Project Delivery Manager for Groundwater Science (or designee) works closely with the Environmental Compliance Officer (ECO), QA, and Sample Management and Reporting (SMR) group to integrate these and other technical disciplines in planning and implementing the work scope. The Project Delivery Manager for Groundwater Science assigns staff to provide technical expertise.

A2.1.5 Sample Management and Reporting Group

The SMR group oversees offsite analytical laboratories, coordinates laboratory analytical work with this plan, and verifies that laboratories are qualified for performing Hanford Site analytical work. They generate field sampling documents, labels, and instructions for field sampling personnel and develop sample authorization forms, which provide information and instruction to the analytical laboratories. The SMR group revises field sampling documents to reflect approved changes. This group's responsibilities include receiving analytical data from the laboratories, performing data entry into the

Hanford Environmental Information System (HEIS) database, arranging for data validation and recordkeeping. The SMR group is responsible for resolving sample documentation deficiencies or issues associated with Field Sample Operations (FSO), laboratories, or other entities. They are responsible for informing the Project Delivery Manager for Groundwater Science (or designee) of any issues reported by the analytical laboratories.

A2.1.6 Field Sample Operations

FSO is responsible for planning and coordinating field sampling resources and provides the Field Work Supervisor (FWS) for routine groundwater sampling operations. The FWS directs the samplers who collect groundwater samples for this groundwater monitoring plan. Samplers collect samples, complete field logbooks, data forms, and chain-of-custody forms, including any shipping paperwork, and assist sample delivery to the analytical laboratory.

A2.1.7 Quality Assurance

The QA point of contact provides independent oversight, is responsible for addressing QA issues on the project, and overseeing implementation of the project QA program.

A2.1.8 Environmental Compliance Officer

ECOs provide technical oversight, direction, and acceptance of project and subcontracted environmental work, with the goal of minimizing adverse environmental impacts.

A2.1.9 Waste Management

Waste Management identifies waste management sampling/characterization activities for regulatory compliance and is responsible for data interpretation to determine waste designations and profiles. Waste Management communicates policies and practices for project compliance for waste storage, transportation, disposal, and tracking in a safe and cost-effective manner.

A2.1.10 Analytical Laboratories

The laboratories maintain custody and analyze samples in accordance with established quality systems and provide data packages containing sample and quality control (QC) results. Laboratories provide explanations of results to support data review and resolve analytical issues.

A2.2 Problem Definition/Background

The purpose of this groundwater monitoring plan is to satisfy *Washington Administrative Code* and *Code of Federal Regulations* requirements (WAC 173-303-400, “Dangerous Waste Regulations,” “Interim Status Facility Standards,” and 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” Subpart F, “Ground-Water Monitoring”) for indicator parameter evaluation. Additional information on the activities to satisfy these requirements is provided in the main text of this monitoring plan.

A2.3 Project/Task Description

The focus of this plan is to monitor the parameters used as indicators of groundwater contamination and for parameters establishing groundwater quality in accordance with 40 CFR 265.92, “Sampling and Analysis;” evaluate the well network; and interpret analytical results. The indicator parameters to be monitored, along with the monitoring wells and frequency of sampling, are provided in the main text (Chapter 2). Information on the collection and analyses of groundwater from the monitoring network is provided in this appendix and in Appendix B.

A2.4 Quality Assurance Objectives and Criteria

The QA objective of this plan is the generation of analytical data of known and appropriate quality. In support of this objective, the process to assess data usability may include data verification, data validation, or a data quality indicator (DQI) evaluation. Principal DQIs are precision, accuracy, representativeness, comparability, completeness, bias, and sensitivity. These DQIs are defined for the purposes of this document in Table A-1.

The applicable QC guidelines, DQI acceptance criteria, and levels of effort for assessing data quality are dictated by the intended use of the data and the requirements of the analytical method. The process to assess data usability is further discussed in Section A4.

A2.5 Documents and Records

The Project Delivery Manager for Groundwater Science (or designee) is responsible for ensuring that the current version of the groundwater monitoring plan is used and providing any updates to field personnel. Table A-2 defines the types of changes that may impact the groundwater monitoring plan and the associated approvals, notifications, and documentation requirements. Elements of the monitoring plan that are required by 40 CFR 265 Subpart F cannot be changed.

Logbooks and data forms are used to document field activities. The logbooks are identified with a unique project name and number. Individuals responsible for the logbooks are identified in the front of the logbook, and only authorized individuals may make entries into the logbooks. Logbooks will be controlled documents. Data forms are also identified with a unique project name and number, may be used to record the same field information as logbooks, and are referenced in the logbooks.

The FWS, SMR group, and field crew supervisors are responsible for alignment of field instructions with the groundwater monitoring plan.

Convenience copies of laboratory analytical results are maintained in the HEIS database. Records may be stored in either electronic (e.g., in the managed records area of the Integrated Document Management System) or hardcopy format (e.g., DOE Records Holding Area). Records of analyses required by 40 CFR 265.94, “Recordkeeping and Reporting,” are to be maintained throughout the active life of a facility and post-closure care period (if any).

By March 1, groundwater monitoring results are reported in the Hanford Site groundwater monitoring report (e.g., DOE/RL-2019-65, *Hanford Site RCRA Groundwater Monitoring Report for 2019*).

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element) ^a	Definition	Determination Methodologies	Possible Corrective Actions
Precision (field duplicates, laboratory sample duplicates, and matrix spike duplicates)	Precision measures the agreement among a set of replicate measurements. Field precision is assessed through the collection and analysis of field duplicates. Analytical precision is estimated by duplicate/replicate analyses, usually on laboratory control samples, spiked samples, and/or field samples. The most commonly used estimates of precision are the relative standard deviation and, when only two samples are available, the relative percent difference.	Use the same analytical instrument to make repeated analyses on the same sample. Use the same method to make repeated measurements of the same sample within a single laboratory. Acquire replicate field samples for information on sample acquisition, handling, shipping, storage, preparation, and analytical processes and measurements.	If duplicate data do not meet objective: <ul style="list-style-type: none"> • Evaluate apparent cause (e.g., sample heterogeneity). • Request reanalysis or remeasurement. • Qualify the data before use.
Accuracy (laboratory control samples, matrix spikes, and surrogates)	Accuracy is the closeness of a measured result to an accepted reference value. Accuracy is usually measured as a percent recovery. QC analyses used to measure accuracy include laboratory control samples, spiked samples, and surrogates.	Analyze a reference material or reanalyze a sample to which a material of known concentration or amount of pollutant has been added (a spiked sample).	If recovery does not meet objective: <ul style="list-style-type: none"> • Qualify the data before use. • Request reanalysis or remeasurement. • Determine if follow-up evaluation is needed. • Evaluate instrumentation and recalibrate, if necessary
Representativeness (field duplicates)	Sample representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. It is dependent on the proper design of the sampling program and will be satisfied by ensuring that the approved plans were followed during sampling and analysis.	Evaluate whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the environment or condition being measured or studied.	If results are not representative of the system sampled: <ul style="list-style-type: none"> • Identify the reason for results not being representative. • Flag for further review. • Review data for usability. • If data are usable, qualify the data for limited use and define the portion of the system that the data represent. • If data are not usable, flag as appropriate. • Redefine sampling and measurement requirements and protocols. • Resample and reanalyze, as appropriate.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)^a	Definition	Determination Methodologies	Possible Corrective Actions
Comparability (field duplicate, field splits, laboratory control samples, matrix spikes, and matrix spike duplicates)	Comparability expresses the degree of confidence with which one data set can be compared to another. It is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the approved plans are followed and that proper sampling and analysis techniques are applied.	Use identical or similar sample collection and handling methods, sample preparation and analytical methods, holding times, and quality assurance protocols.	If data are not comparable to other data sets: <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Qualify the data as appropriate. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future comparability.
Completeness (no QC element; addressed in data usability assessment)	Completeness is a measure of the amount of valid data collected compared to the amount of data planned. Measurements are considered valid if they are unqualified or qualified as estimated data during validation. Field completeness is a measure of the number of samples collected versus the number of samples planned. Laboratory completeness is a measure of the number of valid measurements compared to the total number of measurements planned.	Compare the number of valid measurements completed (samples collected or samples analyzed) with those established by the project's quality criteria (data quality objectives or performance/acceptance criteria).	If data set does not meet the completeness objective: <ul style="list-style-type: none"> • Identify appropriate changes to data collection and/or analysis methods. • Identify quantifiable bias, if applicable. • Resample and/or reanalyze if needed. • Revise sampling/analysis protocols to ensure future completeness.

Table A-1. Data Quality Indicators

Data Quality Indicator (QC Element)^a	Definition	Determination Methodologies	Possible Corrective Actions
Bias (equipment blanks, field transfer blanks, full trip blanks, laboratory control samples, matrix spikes, and method blanks)	Bias is the systematic or persistent distortion of a measurement process that causes error in one direction (e.g., the sample measurement is consistently lower than the sample's true value). Bias can be introduced during sampling, analysis, and data evaluation. Analytical bias refers to deviation in one direction (i.e., high, low, or unknown) of the measured value from a known spiked amount.	Sampling bias may be revealed by analysis of replicate samples. Analytical bias may be assessed by comparing a measured value in a sample of known concentration to an accepted reference value or by determining the recovery of a known amount of contaminant spiked into a sample (matrix spike).	For sampling bias: <ul style="list-style-type: none"> • Properly select and use sampling tools. • Institute correct sampling and subsampling processes to limit preferential selection or loss of sample media. • Use sample handling processes, including proper sample preservation, that limit the loss or gain of constituents to the sample media. • Analytical data that are known to be affected by either sampling or analytical bias are flagged to indicate possible bias. • Laboratories that are known to generate biased data for a specific analyte are asked to correct their methods to remove the bias as practicable. Otherwise, samples are sent to other laboratories for analysis.
Sensitivity (method detection limit, practical quantitation limit, and relative percent difference)	Sensitivity is an instrument's or method's minimum concentration that can be reliably measured (i.e., instrument detection limit or limit of quantitation).	Determine the minimum concentration or attribute to be measured by an instrument (instrument detection limit) or by a laboratory (limit of quantitation). The lower limit of quantitation ^b is the lowest level that can be routinely quantified and reported by a laboratory.	If detection limits do not meet objective: <ul style="list-style-type: none"> • Request reanalysis or remeasurement using methods or analytical conditions that will meet required detection or limit of quantitation. • Qualify/reject the data before use.

Based on SW-846 Compendium (July 2014). Available at: <https://www.epa.gov/hw-sw846/sw-846-compendium>.

a. Acceptance criteria for QC elements are provided in Table A-5.

b. For purposes of this groundwater monitoring plan, the lower limit of quantitation is interchangeable with the practical quantitation limit.

QC = quality control

Table A-2. Change Control for Monitoring Plans

Type of Change	Action	Documentation
Unintentional impact to groundwater monitoring plan that impacts the groundwater quality assessment program requirements of 40 CFR 265, Subpart F, including one-time missed well sampling due to operational constraints, delayed sample collection, broken pump, lost bottle set, missed sampling of groundwater constituents or parameters, or loss of samples in transit.	Project Delivery Manager for Groundwater Science provides informal notification to DOE-RL. DOE-RL provides informal notification to Ecology as appropriate.	Copy of informal notification to Ecology is placed in facility operating record. Annual Hanford Site RCRA groundwater monitoring report.
Planned change to groundwater monitoring activities, including addition or deletion of constituents analyzed for, change of sampling frequency, or changes to well network.	Project Delivery Manager for Groundwater Science obtains DOE-RL approval; revise monitoring plan as appropriate.	Annual Hanford Site RCRA groundwater monitoring report and revised groundwater monitoring plan as appropriate.

40 CFR 265, Subpart F, "Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities," "Ground-Water Monitoring."

DOE-RL = U.S. Department of Energy, Richland Operations Office

Ecology = Washington State Department of Ecology

RCRA = *Resource Conservation and Recovery Act of 1976*

A3 Data Generation and Acquisition

This chapter addresses data generation and acquisition so that the project's methods for sampling, measurement and analysis, data collection or generation, data handling, and QC activities are appropriate and documented. Instrument calibration and maintenance, supply inspections, and data management are also discussed.

A3.1 Analytical Method Requirements

Sample analytical methods are presented in Table A-3. Equivalent (e.g., U.S. Environmental Protection Agency [EPA] Method 300 and SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, Method 9056) or updated (e.g., updates to SW-846 methods) Washington State Department of Ecology-accredited methods may be substituted for the methods identified in Table A-3. The updated methods will be able to achieve the practical quantitation limits identified in Table A-3.

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
General Chemistry			
ALKALINITY	Alkalinity, total as CaCO ₃	310.1, Standard Method 2320, Standard Method 4500	5250
57-12-5 ^b	Cyanide (free)	9014	4

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
57-12-5	Cyanide (total)	335.4, 9012, 9014, Standard Method 4500	10.5
18496-25-8	Sulfide (total)	376.1, Standard Method 4500S	2100
TOC	Total organic carbon	9060	1050
59473-04-0	Total organic halogen	9020	31.5
Anions^c			
16887-00-6	Chloride	300, 9056	400
14797-55-8	Nitrate, as NO ₃	300, 9056	525
14808-79-8	Sulfate	300, 9056	1050
Field Measurements			
--	pH	150.1, 9040, Standard Method 4500 H ⁺	N/A
--	Dissolved oxygen	360.1, Standard Method 4500 O	N/A
--	Specific conductance	120.1, 9050, Standard Method 2520 B-97	N/A
--	Temperature	170.1	N/A
--	Turbidity	180.1, Standard Method 2130 B	N/A
Metals			
7440-36-0	Antimony	6020	5.25
7440-38-2	Arsenic	6020	10.5
7440-39-3	Barium	6020	5.25
7440-41-7	Beryllium	6020	1.05
7440-43-9	Cadmium	6020	2.1
7440-70-2	Calcium	6010	1050
7440-47-3	Chromium	6020	10.5
7440-48-4	Cobalt	6020	5.25
7440-50-8	Copper	6020	12.6
7439-89-6	Iron	6010	105
7439-92-1	Lead	6020	3.15

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
7439-95-4	Magnesium	6010	1050
7439-95-4	Manganese	6020	5.25
7439-97-6	Mercury	7470	0.5
7439-98-7	Molybdenum	6020	5.25
7440-02-0	Nickel	6020	21
7440-09-7	Potassium	6010	5250
7782-49-2	Selenium	6020	10.5
7440-22-4	Silver	6020	5.25
7440-23-5	Sodium	6010	1050
7440-28-0	Thallium	6020	2.1
7440-31-5	Tin	6020	10.5
7440-62-2	Vanadium	6010	52.5
7440-66-6	Zinc	6010	21
Volatile Organic Compounds			
75-34-3	1,1-Dichloroethane	8260	10
75-35-4	1,1-Dichloroethene (1,1-Dichloroethylene)	8260	10
71-55-6	1,1,1-Trichloroethane	8260	5
630-20-6	1,1,1,2-Tetrachloroethane	8260	2.1
79-00-5	1,1,2-Trichloroethane	8260	5
79-34-5	1,1,2,2-Tetrachloroethane	8260	5
96-12-8	1,2-Dibromo-3-Chloropropane	8260	5.25
106-93-4	1,2-Dibromoethane (Ethylene Dibromide [EDB])	8260	5
107-06-2	1,2-Dichloroethane	8260	5
78-87-5	1,2-Dichloropropane	8260	5
156-60-5	trans-1,2-Dichloroethylene	8260	5
96-18-4	1,2,3-Trichloropropane	8260	5
10061-01-5	cis-1,3-Dichloropropene	8260	5
10061-02-6	trans-1,3-Dichloropropene	8260	5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
110-57-6	trans-1,4-Dichloro-2-butene	8260	50
78-93-3	2-Butanone (Methyl Ethyl Ketone [MEK])	8260	10.5
67-64-1	2-Propanone (Acetone)	8260	20
591-78-6	2-Hexanone (Methyl Butyl Ketone [MBK])	8260	20
108-10-1	4-Methyl-2-Pentanone (Methyl Isobutyl Ketone [MIBK])	8260	10.5
75-05-8	Acetonitrile (Methyl Cyanide)	8260	100
107-02-8	Acrolein	8260	100
107-13-1	Acrylonitrile	8260	100
107-05-1	Allyl Chloride	8260	10.5
71-43-2	Benzene	8260	5
75-27-4	Bromodichloromethane	8260	5
75-25-2	Bromoform	8260	5
75-15-0	Carbon Disulfide	8260	10.5
56-23-5	Carbon Tetrachloride	8260	3
108-90-7	Chlorobenzene	8260	5
75-00-3	Chloroethane	8260	10
67-66-3	Chloroform	8260	5
126-99-8	Chloroprene (Chloro-1,3-butadiene;2-)	8260	10
124-48-1	Dibromochloromethane	8260	5
106-46-7	P-Dichlorobenzene (1,4-Dichlorobenzene)	8260	4
75-71-8	Dichlorodifluoromethane	8260	10
100-41-4	Ethylbenzene	8260	4
97-63-2	Ethyl Methacrylate	8260	10.5
78-83-1	Isobutanol (Isobutyl alcohol)	8260	500

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method^a	Practical Quantitation Limit (µg/L)
126-98-7	Methacrylonitrile (2-Propenenitrile, 2-methyl-)	8260	10.5
74-83-9	Methyl bromide (Bromomethane)	8260	10
74-87-3	Methyl chloride (Chloromethane)	8260	10
74-88-4	Methyl iodide (Iodomethane)	8260	10.5
80-62-6	Methyl methacrylate (2-Propenoic acid, 2-methyl-, methyl ester)	8260	10.5
74-95-3	Methylene bromide (Dibromomethane)	8260	10
75-09-2	Methylene Chloride (Dichloromethane)	8260	5.25
107-12-0	Propionitrile (Ethyl cyanide)	8260	21
100-42-5	Styrene	8260	5
127-18-4	Tetrachloroethene (Tetrachloroethylene, perchloroethylene)	8260	5
108-88-3	Toluene	8260	5
79-01-6	Trichloroethylene (Trichloroethene [TCE])	8260	2.1
75-69-4	Trichlorofluoromethane	8260	10
108-05-4	Vinyl Acetate	8260	50
75-01-4	Vinyl Chloride (Chloroethene, chloroethylene)	8260	2.1
1330-20-7	Xylene (Total)(Mixed Isomers)	8260	10
Semivolatile Organic Compounds			
134-32-7	1-Naphthylamine	8270	25
95-50-1	1,2-Dichlorobenzene (o-Dichlorobenzene)	8270	10.5
120-82-1	1,2,4-Trichlorobenzene	8270	13
95-94-3	1,2,4,5-Tetrachlorobenzene	8270	20
123-91-1	1,4-Dioxane (1,4-Diethylene Dioxide)	8270	21

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
130-15-4	1,4-Naphthoquinone	8270	52.5
53-96-3	2-Acetylaminofluorene	8270	100
91-58-7	2-Chloronaphthalene (Beta-chloronaphthalene)	8270	10.5
95-57-8	2-Chlorophenol	8270	10.5
95-48-7	2-Methylphenol (o-Cresol)	8270	10.5
91-57-6	2-Methylnaphthalene	8270	10.5
91-59-8	2-Naphthylamine	8270	10.5
88-75-5	2-Nitrophenol (o-Nitrophenol)	8270	10.5
109-06-8	2-Picoline	8270	21
58-90-2	2,3,4,6-Tetrachlorophenol	8270	52.5
120-83-2	2,4-Dichlorophenol	8270	10.5
105-67-9	2,4-Dimethylphenol (2,4-Xylenol)	8270	10.5
51-28-5	2,4-Dinitrophenol	8270	50
121-14-2	2,4-Dinitrotoluene	8270	10.5
95-95-4	2,4,5-Trichlorophenol	8270	10.5
88-06-2	2,4,6-Trichlorophenol	8270	10.5
87-65-0	2,6-Dichlorophenol	8270	10.5
606-20-2	2,6-Dinitrotoluene	8270	10.5
56-49-5	3-Methylcholanthrene	8270	21
108-39-4 ^d	3-Methylphenol (m-Cresol)	8270	--
106-44-5 ^d	4-Methylphenol (p-Cresol)	8270	--
91-94-1	3,3'-Dichlorobenzidine	8270	52.5
119-93-7	3,3'-Dimethylbenzidine	8270	50
92-67-1	4-Aminobiphenyl	8270	52.5
101-55-3	4-Bromophenyl phenyl ether	8270	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
59-50-7	4-Chloro-3-methylphenol (p-Chloro-m-cresol)	8270	10.5
7005-72-3	4-Chlorophenyl phenyl ether	8270	10.5
56-57-5	4-Nitroquinoline 1-oxide	8270	105
534-52-1	4,6-Dinitro-O-cresol (4,6-Dinitro-2-methyl phenol)	8270	52.5
99-55-8	5-Nitro-o-toluidine (methyl-5-nitroaniline;2-)	8270	21
57-97-6	7,12-Dimethylbenz[a]anthracene	8270	21
83-32-9	Acenaphthene	8270	10.5
208-96-8	Acenaphthylene	8270	10.5
98-86-2	Acetophenone	8270	10.5
62-53-3	Aniline	8270	10.5
120-12-7	Anthracene	8270	10.5
140-57-8	Aramite	8270	20
56-55-3	Benz[a]anthracene (Benzo[a]anthracene)	8270	10.5
205-99-2	Benz[e]acephenanthrylene (Benzo[b]fluoranthene)	8270	10.5
207-08-9	Benzo[k]fluoranthene	8270	10.5
191-24-2	Benzo[ghi]perylene	8270	10.5
50-32-8	Benzo[a]pyrene	8270	10.5
100-51-6	Benzyl Alcohol	8270	10.5
111-91-1	Bis(2-chloroethoxy)methane	8270	10.5
111-44-4	Bis(2-chloroethyl)ether	8270	10.5
108-60-1	Bis(2-chloro-1-methylethyl)ether (2,2'-Oxybis[1-chloropropane])	8270	10.5
117-81-7	Bis(2-ethylhexyl) Phthalate	8270	10.5
85-68-7	Butyl Benzyl Phthalate (Benzyl Butyl Phthalate)	8270	10.5
106-47-8	p-Chloroaniline (4-Chloroaniline)	8270	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
218-01-9	Chrysene	8270	10.5
53-70-3	Dibenz[a,h]anthracene (Dibeznanthracene, 1,2,5,6-)	8270	10.5
132-64-9	Dibenzofuran	8270	10.5
541-73-1	m-Dichlorobenzene (1,3-Dichlorobenzene)	8270	10.5
84-66-2	Diethyl phthalate	8270	10.5
297-97-2	O,O-Diethyl O-2-pyrazinyl phosphorothioate (Thionazin)	8270	52.5
60-11-7	p-(Dimethylamino)azobenzene	8270	21
122-09-8	alpha, alpha-Dimethylphenethylamine	8270	52.5
131-11-3	Dimethyl phthalate	8270	10.5
84-74-2	Di-n-butylphthalate (Dibutyl phthalate)	8270	10.5
99-65-0	m-Dinitrobenzene (1,3-Dinitrobenzene)	8270	10.5
117-84-0	Di-n-octylphthalate	8270	10.5
88-85-7	Dinoseb (2-sec-Butyl-4,6-dinitrophenol)	8270	21
122-39-4	Diphenylamine	8270	10.5
62-50-0	Ethyl methanesulfonate	8270	10.5
206-44-0	Fluoranthene	8270	10.5
86-73-7	9H-Fluorene (Fluorene)	8270	10.5
118-74-1	Hexachlorobenzene	8270	10.5
87-68-3	Hexachlorobutadiene	8270	10.5
77-47-4	Hexachlorocyclopentadiene	8270	10.5
67-72-1	Hexachloroethane	8270	10.5
70-30-4	Hexachlorophene	8270	525
1888-71-7	Hexachloropropene	8270	105
193-39-5	Indeno(1,2,3-Cd)Pyrene	8270	10.5
78-59-1	Isophorone	8270	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
120-58-1	Isosafrole	8270	21
91-80-5	Methapyrilene	8270	52.5
66-27-3	Methyl methanesulfonate	8270	10.5
91-20-3	Naphthalene	8270	10.5
98-95-3	Nitrobenzene	8270	10.5
88-74-4	o-Nitroaniline (2-Nitroaniline)	8270	21
99-09-2	m-Nitroaniline (3-Nitroaniline)	8270	21
100-01-6	p-Nitroaniline (4-Nitroaniline)	8270	21
100-02-7	p-Nitrophenol (4-Nitrophenol)	8270	21
924-16-3	N-Nitrosodi-n-butylamine	8270	10.5
55-18-5	N-Nitrosodiethylamine	8270	10.5
62-75-9	N-Nitrosodimethylamine (Dimethyl nitrosamine)	8270	10.5
86-30-6 ^e	N-Nitrosodiphenylamine	8270	--
621-64-7	n-Nitroso-di-n-dipropylamine (N-Nitrosodipropylamine; Di-n-propylnitrosamine)	8270	10.5
10595-95-6	N-Nitrosomethylethylamine (Ethanamine, N-methyl-N-nitroso-)	8270	10.5
59-89-2	n-Nitrosomorpholine	8270	10.5
100-75-4	N-Nitrosopiperidine	8270	10.5
930-55-2	N-Nitrosopyrrolidine	8270	10.5
608-93-5	Pentachlorobenzene	8270	10.5
76-01-7	Pentachloroethane	8270	52.5
82-68-8	Pentachloronitrobenzene	8270	52.5
87-86-5	Pentachlorophenol	8270	52.5
62-44-2	Phenacetin	8270	21
85-01-8	Phenanthrene	8270	10.5

Table A-3. Analytical Methods for the DWMU

CAS Number	Waste Constituent (Alternate Name)	Analytical Method ^a	Practical Quantitation Limit (µg/L)
108-95-2	Phenol	8270	10.5
106-50-3	p-Phenylenediamine	8270	525
129-00-0	Pyrene	8270	10.5
110-86-1	Pyridine	8270	21
94-59-7	Safrole	8270	21
3689-24-5	Tetraethyl dithiopyrophosphate (Sulfotep)	8270	50
95-53-4	o-Toluidine (methylaniline;2-)	8270	20
126-68-1	O,O,O-Triethyl phosphorothioate	8270	52.5
99-35-4	sym-Trinitrobenzene (trinitrobenzene;1,3,5-)	8270	52.5

Note: Analytical methods and PQLs provided in this table do not represent EPA nor Ecology requirements but are intended solely as guidance.

a. For EPA Methods 180.1, 300, and 335.4 see EPA/600/R-93/100, *Methods for the Determination of Inorganic Substances in Environmental Samples*. For EPA Methods 120.1, 150.1, 170.1, 310.1, 360.1, and 376.1 EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*. For four-digit EPA methods, see SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Compendium*. For Standard Methods, see APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*.

b. Analyzed and reported as free cyanide.

c. Dilutions for certain ion chromatography constituents may be necessary, potentially raising the PQL above the limits provided.

d. Analyzed and reported as 3 & 4 Methylphenol (CAS number 65794-96-9). PQL for 3 & 4 Methylphenol is 20 µg/L.

e. Analyzed and reported as Diphenylamine+N-Nitrosodiphenylamine. PQL for Diphenylamine+N-Nitrosodiphenylamine is 10.5 µg/L.

CAS = Chemical Abstracts Service

N/A = not applicable

Ecology = Washington State Department of Ecology

PQL = practical quantitation limit

EPA = U.S. Environmental Protection Agency

A3.2 Field Analytical Methods

Field screening and survey data will be measured in accordance with applicable work practices. Field analytical methods may also be performed in accordance with manufacturer manuals. Appendix B provides further discussion on field measurements.

A3.3 Quality Control

Field QC samples will be collected to evaluate the potential for cross-contamination and to provide information pertinent to sampling variability. Laboratory QC samples estimate the precision, bias, and matrix effects on the analytical data. Field and laboratory QC samples, and their typical frequencies, are summarized in Table A-4. Acceptance criteria for field and laboratory QC are shown in Table A-5. Data will be qualified and flagged in the HEIS database, as appropriate.

Table A-4. QC Samples

Sample Type	Frequency	Characteristics Evaluated
Field QC		
Equipment blanks	As needed ^a	Contamination from nondedicated sampling equipment
Field duplicates	One in 20 well trips ^b	Reproducibility/sampling precision
Field splits	As needed	Interlaboratory comparability
Field transfer blanks	One each day VOCs are sampled; additional field transfer blanks are collected if VOC samples are acquired on the same day for multiple laboratories	Contamination from sampling site
Full trip blanks	One in 20 well trips ^b	Contamination from containers preservative reagents, storage, or transportation
Analytical QC^c		
Laboratory control samples	One per analytical batch ^d	Method accuracy
Laboratory sample duplicates	One per analytical batch ^d	Laboratory reproducibility and precision
Matrix spikes	One per analytical batch ^d	Matrix effect/laboratory accuracy
Matrix spike duplicates	One per analytical batch ^d	Laboratory reproducibility, and method accuracy and precision
Method blanks	One per analytical batch ^d	Laboratory contamination
Surrogates	Added to each sample and QC sample	Recovery/yield for organic compounds

Note: The information in this table does not create U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

a. For portable pumps, equipment blanks are collected (1 for every 20 well trips). Whenever a new type of nondedicated equipment is used, an equipment blank will be collected each time sampling occurs until it can be shown that less frequent collection of equipment blanks is adequate to monitor the decontamination methods for the nondedicated equipment.

b. A “well trip” is defined as any time a well is accessed for sampling. For groundwater monitoring, field duplicates and full trip blanks are run at a frequency of 1 in 20 well trips (i.e., 5% of the well trips) for all groundwater monitoring wells sampled within any given month (not just those restricted to a single treatment, storage, and disposal unit). For example, if a month has 181 wells scheduled, then 10 field duplicates will be collected.

c. A batch is a group of up to 20 samples which behave similarly with respect to the sampling or testing procedures being employed and which are processed as a unit. Batching across projects is allowed for similar matrices (e.g., Hanford Site groundwater).

d. Unless not required by, or different frequency is called out, in laboratory analysis method.

QC = quality control

VOC = volatile organic compound

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
General Chemistry			
Alkalinity	MB	<MDL <5% Sample concentration	Flag with "C"
	LCS	80% to 120% Recovery	Flag with "o" ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% Recovery	Flag with "N"
	EB, FTB	<MDL <5% Sample concentration	Flag with "Q"
	Field duplicate ^c	≤20% RPD	Review data ^e
Cyanide	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o" ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate ^c	≤20% RPD	Review data ^e
Sulfide	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o" ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate ^c	≤20% RPD	Review data ^e
Total organic carbon	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o" ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with "N"
	EB, FTB	<MDL <5% sample concentration	Flag with "Q"
	Field duplicate ^c	≤20% RPD	Review data ^e
Total organic halogen	MB	<MDL <5% sample concentration	Flag with "C"
	LCS	80% to 120% recovery	Flag with "o" ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with "N"

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e
Anions			
Anions by ion chromatography	MB	<MDL <5% sample concentration	Flag with “C”
	LCS	80% to 120% recovery	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with “N”
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e
Metals			
Metals by inductively coupled plasma/atomic emission spectrometry	MB	<MDL <5% sample concentration	Flag with “C”
	LCS	80% to 120% recovery	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with “N”
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e
Metals by inductively coupled plasma/mass spectrometry	MB	<MDL <5% sample concentration	Flag with “C”
	LCS	80% to 120% recovery	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with “N”
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e
Mercury by cold-vapor atomic absorption	MB	<MDL <5% sample concentration	Flag with “C”
	LCS	80% to 120% recovery	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	75% to 125% recovery	Flag with “N”
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
Volatile Organic Compounds			
Volatile organics by gas chromatography/mass spectrometry	MB	<MDL ^f <5% Sample concentration	Flag with “B”
	LCS	70% to 130% recovery or % recovery statistically derived ^g	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	70% to 130% recovery	Flag with “T”
	SUR	70% to 130% recovery	Review data ^e
	EB, FTB, FXR	<MDL ^f <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e
Semivolatile Organic Compounds			
Phenols gas chromatography/mass spectrometry	MB	<MDL <5% sample concentration	Flag with “B”
	LCS	70% to 130% recovery or % recovery statistically derived ^g	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	% recovery statistically derived ^g	Flag with “T”
	SUR	% recovery statistically derived ^g	Review data ^e
	EB, FTB	<MDL <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e
Semivolatiles by gas chromatography/mass spectrometry	MB	<MDL ^f <5% sample concentration	Flag with “B”
	LCS	70% to 130% recovery or % recovery statistically derived ^g	Flag with “o” ^b
	DUP ^c or MS/MSD ^d	≤20% RPD	Review data ^e
	MS/MSD ^d	% recovery statistically derived ^g	Flag with “T”
	SUR	% recovery statistically derived ^g	Review data ^e
	EB, FTB	<MDL ^f <5% sample concentration	Flag with “Q”
	Field duplicate ^c	≤20% RPD	Review data ^e

Notes: The information in this table does not create U.S. Environmental Protection Agency or Washington State Department of Ecology requirements; it is intended solely as guidance.

This table applies only to laboratory analyses. Field measurements (e.g., specific conductance, pH, dissolved oxygen temperature, and turbidity) are not listed because they are measured in the field.

a. See Table A-3 for constituent list and analytical methods.

b. The reporting laboratory will apply the “o” flag with Sample Management and Reporting group concurrence.

c. Applies when at least one result is greater than the laboratory PQL.

Table A-5. Field and Laboratory QC Elements and Acceptance Criteria

Analyte ^a	QC Element	Acceptance Criteria	Corrective Action
d. Either a DUP or a MS/MSD is to be analyzed to determine measurement precision (if there is insufficient sample volume, a laboratory control sample duplicate is analyzed with the acceptance criteria defaulting to the ≤20% RPD criteria).			
e. After review, corrective actions are determined on a case-by-case basis. Corrective actions may include a laboratory recheck or flagging the data.			
f. For common laboratory contaminants such as acetone, methylene chloride, 2-butanone, toluene, and phthalate esters, the acceptance criteria is <5 times the MDL.			
g. Laboratory determined, statistically derived control limits based on historical data are used here. Control limits are reported with the data.			
DUP	= laboratory sample duplicate	MDL	= method detection limit
EB	= equipment blank	MS	= matrix spike
FTB	= full trip blank	MSD	= matrix spike duplicate
FXR	= field transfer blank	PQL	= practical quantitation limit
LCS	= laboratory control sample	RPD	= relative percent difference
MB	= method blank	SUR	= surrogate
Data Flags			
B, C	= possible laboratory contamination: analyte was detected in the associated method blank – laboratory applied. The B flag is used for organic analytes. The C flag is used for general chemical and inorganic analytes.		
N	= result may be biased: associated matrix spike result was outside the acceptance limits (except gas chromatograph/mass spectrometry) – laboratory applied.		
o	= result may be biased: associated laboratory control sample result was outside the acceptance limits – laboratory applied.		
Q	= problem with associated field QC blank: results were out of limits – SMR review.		
T	= result may be biased: associated matrix spike result was outside the acceptance limits (gas chromatograph/mass spectrometry only) – laboratory applied.		

A3.3.1 Field Quality Control Samples

Field QC samples are used to monitor the integrity of field samples during sample collection, transportation, storage, and laboratory analysis. Field QC samples are submitted to the analyzing laboratories as field samples. Field QC samples are analyzed for the same set of analytes as their corresponding field samples. Field QC samples include field duplicates, field split (SPLIT) samples, and field blanks (equipment blanks [EBs], field transfer blanks [FXRs], and full trip blanks [FTBs]). Field blanks are typically prepared to match the sample matrix as closely as possible using high-purity water¹. The following describe the QC samples in more detail:

- **Equipment blanks:** EBs are used to monitor the effectiveness of the decontamination process for reusable sampling equipment. They are samples of high-purity water contacted with the sampling surfaces of equipment used to collect samples prior to using that equipment for field sampling. EBs are collected from each type of reusable sampling equipment to ensure that the decontamination procedures are effective for the specific equipment types. EBs will be analyzed for the same analytes as samples collected using that equipment. EB samples are not required for disposable sampling equipment.

¹ High-purity water is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques.

- **Field duplicates:** Field duplicates provide information regarding the homogeneity of the sample matrix and the precision of the sampling and analysis processes. Field duplicates are two samples that are intended to be identical and are collected as close as possible in time and location. Each sample in the sample-duplicate pair receives its own unique sample number.
- **Field splits:** SPLITs are two samples that are intended to be identical and are collected as close as possible in time and location. SPLITs will be stored in separate containers and analyzed by different laboratories for the same analytes. SPLITs are interlaboratory comparison samples used to evaluate comparability between laboratories.
- **Field transfer blanks:** FXRs are used to document possible contamination during field acquisition of volatile organic compound (VOC) samples. FXRs are sample bottles (already containing any required sample preservative) filled at the sample collection site with high-purity water. The blank is sealed at the sampling site and becomes part of the sample set sent to the laboratory. FXRs are prepared daily for sites sampling for VOC analysis. Typically, one set of FXRs is prepared each day that VOC field samples are collected. If VOC samples are collected on the same day and shipped to multiple laboratories, a set of FXRs is collected for each analyzing laboratory.
- **Full trip blanks:** FTBs are used to monitor for potential sample contamination from the sampling container, preservation reagents, or storage conditions. FTBs are prepared with high-purity water and sealed prior to traveling to the sampling site, transported to the sampling site (not opened in the field), and then shipped as part of the sample set to the laboratory. The bottle set is either for volatile organic analysis only or identical to the set that will be collected in the field. Collected FTBs are typically analyzed for the same constituents as the samples from the associated sampling event.

A3.3.2 Laboratory Quality Control Samples

Internal QA/QC programs are maintained by laboratories used by the project and include the use of laboratory control samples (LCSs), laboratory sample duplicates (DUPs), matrix spikes (MSs), matrix spike duplicates (MSDs), method blanks (MBs), and surrogates (SURs). These QC analyses follow EPA methods (e.g., those in the SW-846 Compendium). QC checks outside of control limits are documented in analytical laboratory reports and during a DQI evaluation. Descriptions of the various types of laboratory QC samples are as follows:

- **Laboratory control sample:** A control matrix (e.g., reagent water) spiked with analytes representative of the target analytes or a certified reference material that is used to evaluate laboratory accuracy.
- **Laboratory sample duplicate:** A second aliquot of a sample that is taken through the entire sample preparation and analytical process. DUPs are used to evaluate the precision of a method in a given sample matrix.
- **Matrix spike:** An aliquot of a sample spiked with a known concentration of target analyte(s) that is then taken through the entire sample preparation and analytical process. An MS is used to assess the bias of a method in a given sample matrix. Thus, MS results are an indicator of the effect the sample matrix has on the accuracy of measurement of the target analytes
- **Matrix spike duplicate:** A replicate spiked aliquot of a sample that is subjected to the entire sample preparation and analytical process. MSD results are used to determine the bias and precision of a method in a given sample matrix.

- **Method blank:** An analyte-free matrix to which the same reagents are added in the same volumes or proportions as used in the sample processing. The MB is carried through the complete sample preparations and analytical process. The MB is used to quantify contamination resulting from the sample preparation and analysis.
- **Surrogate:** Used only in organic analyses, a compound added to every sample in the analysis batch (field samples and QC samples) prior to preparation. SURs are typically similar in chemical composition to the analyte being determined, but they are not normally encountered. SURs are expected to respond to the preparation and analytical process in a manner similar to the analytes of interest. Because SURs are added to every sample and QC sample, they are used to evaluate overall method performance in a given matrix.

Samples are analyzed within the holding times guidelines provided in Table A-6. In some instances, constituents in the samples not analyzed within the holding times may be compromised by volatilization, decomposition, or other chemical changes. Data from samples analyzed outside of the holding times are flagged in the HEIS database with an “H.”

Table A-6. Preservation and Holding Time Guidelines for Laboratory Analyses

Constituent ^a	Preservation ^b	Holding Time
General Chemistry		
Alkalinity	Store ≤6°C	14 days
Cyanide	Store ≤6°C, Adjust pH to >12 with 50% sodium hydroxide. If oxidizing agents present, add 5 mL 0.1 N sodium arsenite/L or 0.06 g ascorbic acid/L	14 days
Sulfide	Store ≤6°C, adjust pH to > 9 with zinc acetate and sodium hydroxide	7 days
Total organic carbon	Store <6°C, adjust pH to <2 with sulfuric acid or hydrochloric acid	28 days
Total organic halogen	Store <6°C, adjust pH to <2 with sulfuric acid	28 days
Anions		
Chloride, sulfate	Store ≤6°C	28 days
Nitrate	Store ≤6°C	48 hours
Metals		
Metals by inductively coupled plasma-atomic emission spectrometry	Adjust pH to <2 with nitric acid	6 months
Metals by inductively coupled plasma/mass spectrometry	Adjust pH to <2 with nitric acid	6 months
Mercury by cold-vapor atomic absorption	Adjust pH to <2 with nitric acid	28 days

Table A-6. Preservation and Holding Time Guidelines for Laboratory Analyses

Constituent ^a	Preservation ^b	Holding Time
Volatile Organic Compounds		
Volatile organics by gas chromatography/mass spectrometry	Store $\leq 6^{\circ}\text{C}$, adjust pH to < 2 with sulfuric acid or hydrochloric acid	7 days unpreserved 14 days maximum preserved
Semivolatile Organic Compounds		
Phenols by gas chromatography/mass spectrometry	Store $\leq 6^{\circ}\text{C}$	7 days before extraction 40 days after extraction
Semivolatiles by gas chromatography/mass spectrometry	Store $\leq 6^{\circ}\text{C}$	7 days before extraction 40 days after extraction

Notes: Holding times and preservation methods are dependent on the constituent and are consistent with EPA guidance and approved analytical methods. Information in this table does not create EPA or Washington State Department of Ecology requirements but is intended solely as guidance.

The container type for a sample is available on the chain-of-custody documentation.

This table applies only to laboratory analyses. Field measurements (e.g., specific conductance, pH, dissolved oxygen, temperature, and turbidity) are not listed because they are measured in the field.

a. See Table A-3 for constituent list and analytical methods.

b. For preservation identified as stored at $\leq 6^{\circ}\text{C}$, the sample should be protected against freezing unless it is known that freezing will not impact the sample integrity.

EPA = U.S. Environmental Protection Agency

A3.4 Measurement Equipment

Each measuring equipment user will ensure that equipment is functioning as expected, properly handled, and properly calibrated per methods governing control of the measuring equipment. Onsite environmental instrument testing, inspection, calibration, and maintenance will be recorded according to approved methods. Field screening instruments will be used, maintained, and calibrated as provided in manufacturer specifications and other approved methods.

A3.5 Instrument and Equipment Testing, Inspection, and Maintenance

Collection, measurement, and testing equipment will meet applicable standards (e.g., ASTM International, formerly the American Society for Testing and Materials) or have been evaluated as acceptable and valid according to instrument-specific methods and specifications. Software applications will be acceptance tested prior to use in the field. Measurement and testing equipment used in the field will be subject to preventive maintenance measures to minimize downtime.

A3.6 Instrument/Equipment Calibration and Frequency

Field equipment calibration is discussed in Appendix B.

A3.7 Inspection/Acceptance of Supplies and Consumables

Consumables, supplies, and reagents will be reviewed per test methods in the SW-846 Compendium and EPA/600 Method series (e.g., EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*), and will be appropriate for their use. Supplies and consumables used in sampling and analysis activities are procured under internal work processes. Supplies and consumables are checked and accepted by users prior to use.

A3.8 Nondirect Measurements

Data obtained from sources such as computer databases, programs, literature files, and historical records will be evaluated by staff assigned by the Project Delivery Manager for Groundwater Science. Data used in evaluations will be identified by source. Historical data obtained from the HEIS database is useable for comparison to data collected by this groundwater monitoring plan.

A3.9 Data Management

Records of data analyses and groundwater surface elevations are maintained as required by 40 CFR 265.94.

Electronic data access will be through a Hanford Site database (e.g., HEIS). Where electronic data are not available, hard copies will be provided.

A4 Data Review and Usability

This chapter addresses QA activities that occur after data collection. Implementation of these activities determines whether the data conform to the specified criteria, thus satisfying the project objectives.

A4.1 Data Review and Verification

Data review and verification are performed to confirm that field and field QC sampling and chain-of-custody documentation are complete. This review includes linking sample numbers to specific sampling locations, and reviewing sample collection dates and sample preparation and analysis dates to determine if holding times were met.

The criteria for verification include, but are not limited to, review for contractual compliance (samples were analyzed as requested), use of the correct analytical method, transcription errors, correct application of dilution factors, and the correct application of conversion factors. Data verification is typically conducted on a portion of multi-media samples collected across projects.

The staff member, assigned by the Project Delivery Manager for Groundwater Science, will also perform a data review to determine if observed changes reflect improved/degraded groundwater quality or potential data errors, which may result in a request for data review on questionable data. The laboratory may be asked to check calculations, reanalyze samples, or the well may be resampled. Results of the request for data review process are used to flag data in the HEIS database and to add comments.

A4.2 Data Validation

Data validation is performed at the discretion of the Project Delivery Manager for Groundwater Science, under the direction of the SMR group. The decision to perform validation is based on the results of QC samples for individual well networks and discussions with the staff member assigned by the Project Delivery Manager for Groundwater Science. If conducted, data validation (third-party) will be performed at a minimum frequency of 5% per method. Data validation evaluates the analytical quality of data from samples specifically collected for this plan.

A4.3 Reconciliation with User Requirements

The purpose of reconciliation with user requirements is to determine if quantitative data are of the correct type and are of adequate quality and quantity to meet the project data needs. For routine groundwater monitoring undertaken by projects, DQIs such as precision, accuracy, representativeness, comparability, completeness, and sensitivity for the specific data sets (individual data packages) will typically be evaluated on an annual basis. A DQI evaluation specific to data quality requirements specified in this plan may be performed at the discretion of the Project Delivery Manager for Groundwater Science. Results of the DQI evaluation(s) will be used by the Project Delivery Manager for Groundwater Science to interpret the data and determine if the data quality objectives for this activity have been met.

A5 References

- 40 CFR 265, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” *Code of Federal Regulations*. Available at: <http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5>.
- 265.92, “Sampling and Analysis”
- 265.94, “Recordkeeping and Reporting.”
- Subpart F, “Ground-Water Monitoring.”
- APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*, 23rd Edition, American Public Health Association, American Water Works Association, and Water Environment Federation, Washington, D.C.
- Atomic Energy Act of 1954*, as amended, 42 USC 2011, Pub. L. 83-703, 68 Stat. 919. Available at: <https://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap23-divsnA.htm>.
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Appendix B
Sampling Protocol

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Terms

DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
IATA	International Air Transport Association
NTU	nephelometric turbidity unit
QA	quality assurance
QC	quality control
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>

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B1 Introduction

Groundwater monitoring at the Hanford Site, as defined by the *Resource Conservation and Recovery Act of 1976* (RCRA) and implemented in WAC 173-303, “Dangerous Waste Regulations,” has been conducted since the mid-1980s. Hanford Site groundwater sampling methods contain sampling precautions to be taken; identify equipment and its use; cleaning and decontamination practices; records and documentation; and sample collection, management, and control activities. Together, Appendices A and B discuss the sampling and analysis elements for the groundwater monitoring plan: sample collection, sample preservation and holding times, chain-of-custody control, analytical methods, and field and laboratory quality assurance (QA)/quality control (QC).

This appendix provides elements of the sampling protocols and techniques used for the groundwater monitoring plan. The main text of the groundwater monitoring plan identifies the monitoring wells that will be sampled, constituents to be analyzed, and sampling frequency for the groundwater monitoring at the dangerous waste management unit.

B2 Sampling Methods

Sampling may include but is not limited to the following methods:

- Field screening measurements
- Groundwater sampling
- Water-level measurements

Groundwater samples will be collected according to the current revision of applicable operating methods. Groundwater samples are collected after field measurements of purged groundwater have stabilized:

- **pH** – two consecutive measurements agree within 0.2 pH units
- **Temperature** – two consecutive measurements agree within 0.2°C (0.36°F)
- **Conductivity** – two consecutive measurements agree within 10% of each other
- **Turbidity** – less than 5 nephelometric turbidity units (NTUs) prior to sampling (or project scientist’s recommendation)

Dissolved oxygen will also be measured in the field. Dissolved oxygen is not required to be stable prior to sample collection.

Unless special directions are provided by the staff assigned by the Project Delivery Manager for Groundwater Science at the time of sample collection, wells are typically purged at a flow rate not to exceed 7.6 L/min (2 gal/min). Purging will continue until stable readings of selected field water quality parameters are achieved (as described above).

Field measurements (except for turbidity) are typically obtained using an instrumented flow-through cell located at the well head. Groundwater is pumped directly from the well to the flow-through cell. At the beginning of the sample event, field crews attach a clean stainless steel sampling manifold to the riser discharge. The manifold has two valves and two ports: one port is used only for purgewater, and the other port is used to supply water to the flow-through cell. Probes are inserted into the flow-through cell to measure pH, temperature, specific conductance, and dissolved oxygen. Turbidity is measured by collecting an aliquot of water from the purgewater valve and inserting the sample vial into a turbidimeter.

Purgewater, including the water passing through the flow-through cell, is then discharged to a tank on the purgewater truck.

Collection of the field measurement data will commence when a volume of water equal to the volume of the pump riser pipe has been extracted and discharged to the purgewater truck. Once field measurements have stabilized, the hose supplying water to the flow-through cell is disconnected and a clean stainless steel drop leg is attached for sampling collection. The flow rate does not exceed 7.6 L/min (2 gal/min) during sampling to minimize loss of volatiles (if any) and prevent overfilling the bottles. Sample bottles are filled in a sequence designed to minimize loss of volatiles (if any). If both filtered and unfiltered samples are required, filtered samples are collected after collection of the unfiltered samples.

If required, samples may be filtered in the field, using a 0.45 µm filter, as noted on the chain-of-custody form. Unfiltered samples are collected in conjunction with filtered samples for select analysis to determine if metal constituents being monitored (excluding hexavalent chromium, if one of the monitored constituents) occur as both suspended and dissolved phases, or in only one state. The evaluation of suspended and dissolved metals provide supporting information for groundwater geochemical characteristics, as well as indication of well integrity such as the presence of dislodged well encrustation, well corrosion products, or failure of the well screen filter pack.

Environmental-grade electric submersible pumps will typically be used for well purging and sample collection. In the event a well exhibits insufficient productivity to support purging and sampling using the electric submersible pumps, adjustable-rate bladder pumps with typical flow rates of 0.1 to 0.5 L/min (0.26 to 0.13 gal/min) may be employed. The same purge protocol described above will be used for these pumps.

For certain types of samples, preservatives are required. Preservatives, based on the analytical methods used, are generally added to the collection bottles before their use in the field. Sample preservation and holding times for groundwater samples are provided in Appendix A (Table A-6) and are based on the analytical method identified in Appendix A (Table A-3). Container types, preservatives, and volumes will be identified on the chain-of-custody form. This groundwater monitoring plan defines a sample as a filled sample bottle for purposes of starting the clock for holding time restrictions.

Holding time is the maximum allowable period between sample collection and analysis. Exceeding holding times could result in changes in constituent concentrations due to volatilization, decomposition, or other chemical alterations. Holding times depend on the constituent and are listed in analytical method compilations such as APHA/AWWA/WEF, 2017, *Standard Methods for the Examination of Water and Wastewater*; SW-846, *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods, Third Edition*; and the EPA/600 Method series (e.g., EPA/600/4-79/020, *Methods for Chemical Analysis of Water and Wastes*).

B2.1 Decontamination of Drilling and Sampling Equipment

Drilling of wells is not addressed by this groundwater monitoring plan. Therefore, a discussion of the decontamination of drilling equipment is not included.

Sampling equipment will be decontaminated in accordance with sampling equipment decontamination methods. To prevent potential contamination of the samples, care should be taken to use decontaminated equipment for each specific sampling activity.

Special care should be taken to avoid the following common ways in which cross-contamination or background contamination may compromise the samples:

- Improperly storing or transporting sampling equipment and sample containers
- Contaminating the equipment or sample bottles by setting the equipment/sample bottle on or near potential contamination sources (e.g., uncovered ground)
- Handling bottles or equipment with dirty hands or gloves
- Improperly decontaminating equipment before sampling or between sampling events

Decontamination of sampling equipment and pumps is typically performed using high-purity water¹ in each step. In general, three rinse cycles are performed to decontaminate sampling equipment: detergent rinse, acid rinse, and water rinse. During the detergent rinse, equipment is washed in a phosphate-free detergent solution, followed by rinsing with water in three sequential containers. After the third water rinse, equipment that is stainless steel or glass is rinsed in a 1 M nitric acid solution (pH less than 2). Equipment is then rinsed with water in three sequential containers (the water rinses following the acid rinse are conducted in separate water containers that are not used for detergent rinse). Following the final water rinse, equipment is rinsed in hexane and then placed on a rack to dry. Dry equipment is loaded into a drying oven. The oven is set at approximately 50°C (122°F) for items that are not metal or glass or at approximately 100°C (212°F) for metal or glass. Once reaching temperature, equipment is baked for approximately 20 minutes and then cooled. Equipment is then removed from the oven and enclosed in clean unused aluminum foil using surgical gloves. The wrapped equipment is stored in a custody locked, controlled access area. Water-level measurement tapes (portion that came in contact with groundwater) are decontaminated using a high-purity water rinse and dried with disposable towels.

To decontaminate sampling pumps that are not permanently installed, the pump cowling is first removed, washed (if needed) in phosphate-free detergent solution, and then reinstalled on the pump. Typically, the pump is then submerged in phosphate-free detergent solution, and 11.4 L (3 gal) of solution is pumped through the unit and disposed. Detergent solution is then circulated through the submerged pump for 5 minutes. The pump is removed from solution and rinsed with water. The pump is submerged in water, and 30.3 L (8 gal) of water is pumped through the unit and disposed. The pump is removed from the water, and the intake and housing are covered with plastic sleeving. Cleaning is documented on a tag that is affixed to the pump with the following information:

- Date of pump cleaning
- Pump identification
- Comments (if any)
- Signature of person performing decontamination

¹ High-purity water is generally defined as water that has been distilled, deionized, or any combination of distillation, deionization, reverse osmosis, activated carbon filtration, ion exchange, particulate filtration, or other polishing techniques.

B2.2 Water Levels

Each time a sample is obtained, measurement of the groundwater surface elevation at each monitoring well is required by 40 CFR 265.92(e), “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Sampling and Analysis.” Using a calibrated depth measurement tape, the depth to water is recorded in each well prior to sampling. When two consecutive measurements are taken that agree within 6 mm (0.24 in.), the final determined measurement is recorded, along with the date and time for the specific event. The depth to groundwater is subtracted from the elevation of a reference point (usually the top of the casing) to obtain the water-level elevation. The top of the casing is a known elevation reference point because it has been surveyed to local reference data.

B3 Documentation of Field Activities

Logbooks for field activities are identified with a unique project name and number. The individual(s) responsible for logbooks will be identified in the front of the logbook, and only authorized persons may make entries in logbooks. Logbook entries will be reviewed by the sampling Field Work Supervisor, cognizant scientist/engineer, or other responsible manager; the review will be documented with a signature and date. Logbooks will be permanently bound, waterproof, and ruled with sequentially numbered pages. Pages will not be removed from logbooks for any reason. Entries will be made in indelible ink. Corrections will be made by marking through the erroneous data with a single line, entering the correct data, and initialing and dating the changes.

Data forms for field activities are also identified with a unique project name and number. Data forms may be used to collect field information; information recorded on data forms is the same as for logbooks. The data forms are referenced in the logbooks.

The following information is recorded in logbooks or on data forms:

- Day and date; time task started; weather conditions; and names, titles, and organizations of personnel performing the task
- Purpose of visit to the task area
- Details of field tests that were conducted, and references to forms that were used and methods followed in conducting the activity
- Details of field calibrations and surveys that were conducted, and references to forms that were used, other data records, and methods followed in conducting the calibrations and surveys
- Details of samples collected and the preparation (if any) of splits, duplicates, or blanks
- Time, equipment type, serial or identification number, and methods followed for decontaminations and equipment maintenance performed (reference the page number[s] of any logbook where detailed information is recorded)
- Equipment failures or breakdowns that occurred, with a brief description of replacements

B4 Calibration of Field Equipment

Onsite environmental instruments are calibrated in accordance with the manufacturer's operating instructions, internal work processes, and/or field instructions that provide direction for equipment calibration or verification of accuracy by analytical methods. Calibration records will include the raw calibration data, identification of the standards used, associated reports, date of analysis, and analyst's name or initials. Results from instrument calibration activities are recorded.

Field instrumentation calibration and QA checks will be performed as follows:

- Prior to initial use of a field analytical measurement system
- At a minimum, at the frequency recommended by the manufacturer or methods, or as required by regulations
- Upon failure to meet specified QC criteria
- Daily calibration checks will be performed and documented for each instrument used (these checks will be made on standard materials sufficiently like the matrix under consideration for direct comparison of data; analysis times will be sufficient to establish detection efficiency and resolution)
- Using standards for calibration that are traceable to a nationally recognized standard agency source or measurement system (manufacturer's recommendations for storage and handling of standards, if any, will be followed)

B5 Sample Handling

Sample handling and transfer methods preclude loss of identity, damage, deterioration, and loss of sample. Custody seals or custody tape will be used to verify that sample integrity has been maintained during sample transport. The custody seal will be inscribed with the sampler's initials and date.

A sampling and analytical database is used to track samples from the point of collection through the laboratory analysis process.

B5.1 Containers

Samples will be collected, where and when appropriate, in break-resistant containers. The field sample collection record will indicate the lot number of the bottles used in sample collection. When commercially precleaned containers are used in the field, the name of the manufacturer, lot identification, and certification will be retained for documentation.

Containers will be capped and stored in an environment that minimizes the possibility of sample container contamination. If contamination of the stored sample containers occurs, corrective actions will be implemented to prevent reoccurrences. Contaminated sample containers cannot be used for a sampling event. Container sizes may vary depending on laboratory specific volumes/requirements for meeting analytical detection limits. Container types and sample amounts/volumes are identified on the chain-of-custody form.

B5.2 Container Labeling

Each sample is identified by affixing a standardized label or tag to the container. This label or tag will contain the sample identification number. The label will identify or provide reference to associate the sample with the date and time of collection, preservative used (if applicable), analysis requested, and collector's name or initials. Sample labels may be either preprinted or handwritten in indelible or waterproof ink.

B5.3 Sample Custody

Sample custody protocols maintained sample integrity throughout the analytical process. Chain-of-custody protocols will be followed throughout sample collection, transfer, analysis, and disposal to ensure that sample integrity is maintained. A chain-of-custody record will be initiated in the field at the time of sampling and will accompany each set of samples shipped to any laboratory.

Shipping requirements will determine how sample shipping containers are prepared for shipment. The analyses requested for each sample will be indicated on the accompanying chain-of-custody form. Each time the responsibility for custody of the sample changes, new and previous custodians will sign the record and note the date and time.

The following minimum information is provided on a completed chain-of-custody form:

- Project name
- Collectors' names
- Unique sample number
- Date, time, and location (or traceable reference thereto) of sample collection
- Matrix
- Preservatives
- Chain-of-possession information (i.e., signatures and printed names of each individual involved in the transfer of sample custody and storage locations, and dates/times of receipt and relinquishment)
- Requested analyses (or reference thereto)
- Shipped to information (i.e., analytical laboratory performing the analysis)

B5.4 Sample Transportation

Packaging and transportation instructions will comply with applicable transportation regulations and U.S. Department of Energy (DOE) requirements. Regulations for classifying, describing, packaging, marking, labeling, and transporting hazardous materials, hazardous substances, and hazardous wastes are enforced by the U.S. Department of Transportation (DOT). Carrier specific requirements, defined in the current edition of International Air Transport Association (IATA) *Dangerous Goods Regulations*, will also be considered when preparing sample shipments conveyed by air freight providers.

Samples containing hazardous constituents will be considered hazardous material in transportation and transported according to DOT/IATA requirements. If the sample material is known or can be identified, then it will be classified, described, packaged, marked, labeled, and shipped according to the specific instructions for that material.

B6 Management of Waste

Waste materials generated during sample activities, including purgewater and decontamination fluids, will be collected and managed in accordance with the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* as authorized under Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order Action Plan* Milestone M-024.

For waste designation purposes, wells listed in the main text of the monitoring plan may be surveyed in the Hanford Environmental Information System, and the maximum concentration for each analyte within the most recent 5 years will be evaluated for use in creating a waste profile, if necessary.

Packaging and labeling during waste storage and transportation will meet WAC 173-303, DOE, and DOT requirements, as appropriate.

Offsite analytical laboratories are responsible for the disposal of unused sample quantities and wastes generated during analytical processes.

B7 References

- 40 CFR 265.92, “Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities,” “Sampling and Analysis,” *Code of Federal Regulations*. Available at: <http://www.ecfr.gov/cgi-bin/text-idx?SID=2cd7465519114fb3472b4864a0e3c42b&node=pt40.26.265&rgn=div5>
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Appendix C

Well Construction

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C1 Introduction

This appendix provides the following information for the existing Waste Management Area (WMA) A-AX groundwater monitoring wells:

- Well name
- Hydrogeologic unit monitored (the aquifer portion at the well screen perforation) (Table C-1)
- The following sampling interval information, as provided in Table C-2:
 - Elevation at the top of the screen or perforated interval
 - Elevation at the bottom of the screen or perforated interval
 - Open interval length (i.e., difference between the top and bottom screen perforation elevations)
 - Drilling method

For proposed wells, the following information is provided in Table C-3:

- Well location
- Surface elevation
- Estimated water elevation
- Estimated water depth

Figures C-1 through C-8 provide construction and completion summaries for the existing network wells.

Table C-1. Hydrogeologic Monitoring Unit Classification Scheme

Unit	Description
TU	Top of Unconfined. Screened across the water table or the top of the open interval is within 1.5 m (5 ft) of the water table, and the bottom of the open interval is no more than 10.7 m (35 ft) below the water table.

Table C-2. Sampling Interval Information for Wells Within the WMA A-AX Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])	Drilling Method
299-E24-20	TU	125.0 (410.1)	118.9 (390.0)	6.1 (20.1)	Cable tool
299-E24-22	TU	122.3 (401.3)	111.6 (366.3)	10.7 (35.1)	Becker hammer
299-E24-33	TU	122.2 (400.9)	111.5 (365.9)	10.7 (35.0)	Cable tool
299- E25-40	TU	126.3 (414.4)	119.9 (393.4)	6.4 (21.0)	Cable tool
299- E25-41	TU	126.9 (416.4)	120.5 (395.4)	6.4 (21.0)	Cable tool
299- E25-93	TU	122.5 (401.8)	111.8 (366.7)	10.7 (35.0)	Becker hammer
299- E25-94	TU	121.4 (398.2)	110.7 (363.2)	10.7 (35.0)	Cable tool
299-E25-237	TU	123.2 (404.1)	112.5 (369.1)	10.7 (35.0)	Cable tool

Table C-2. Sampling Interval Information for Wells Within the WMA A-AX Network

Well Name	Hydrogeologic Unit Monitored	Elevation Top of Open Interval (m [ft] NAVD88)	Elevation Bottom of Open Interval (m [ft] NAVD88)	Open Interval Length (m [ft])	Drilling Method
------------------	-------------------------------------	---	--	--------------------------------------	------------------------

Reference: NAVD88, *North American Vertical Datum of 1988*.

*Due to rounding and conversion of metric units, the computed open interval length based on the top and bottom elevations may differ slightly from the actual open interval length reported in Figures C-1 through C-8.

TU = Top of Unconfined, as described in Table C-1

Table C-3. Planned Locations, Surface Elevations, and Estimated Water Elevations and Depths for Proposed Wells Within the WMA A-AX Network

Well ID	Eastings* (m)	Northing* (m)	Surface Elevation (m [ft] NAVD88)	Water Table Elevation (m [ft] NAVD88)	Depth to Water (m [ft] bgs)	Drill Depth (m [ft] bgs)	Final Well Diameter (cm [in.])	Screen Interval (m [ft] bgs)	Sump and End Cap Interval (m [ft] bgs)
WMA_A-AX_PW-1	575381.11	135970.28	212.2 (696.2)	TBD	TBD	TBD	TBD	TBD	TBD
WMA_A-AX_PW-2	575469.93	136087.54	208.8 (685.0)	TBD	TBD	TBD	TBD	TBD	TBD

Reference: NAVD88, *North American Vertical Datum of 1988*.

Note: Well coordinates are estimates and are subject to modification based on final well location survey.

*Coordinates are in Washington State Plane (south zone), NAD83, *North American Datum of 1983*; 1991 adjustment.

bgs = below ground surface

TBD = to be determined. Information will be obtained after well construction.

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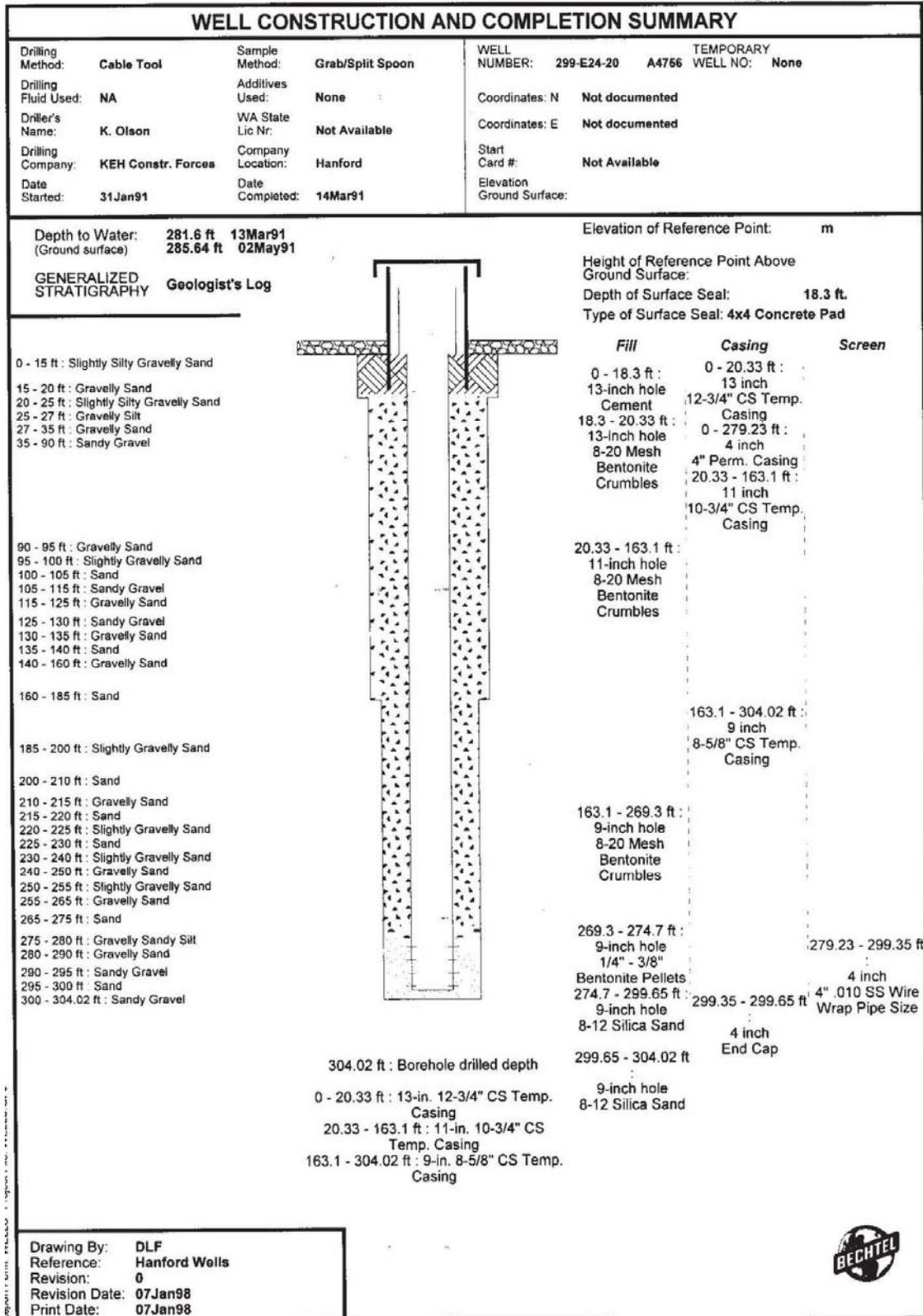


Figure C-1. Well 299-E24-20 Construction and Completion Summary

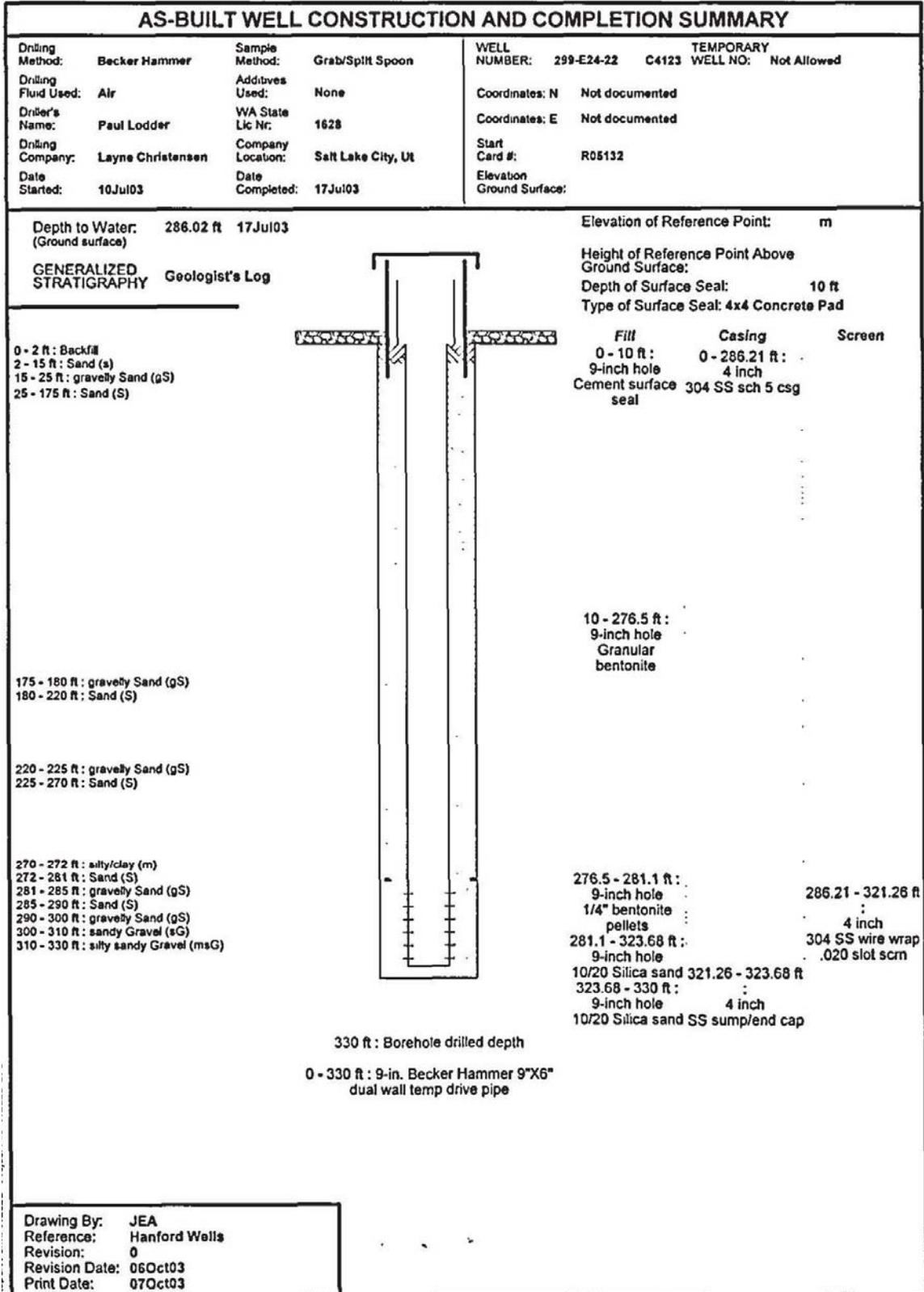


Figure C-2. Well 299-E24-22 Construction and Completion Summary

WELL SUMMARY SHEET		Start Date: 04/16/04		Page 1 of 2		
		Finish Date: 06/02/04				
Well ID: C4257		Well Name: 299-E24-33				
Location: n. west of Ax Tank Farm/300 East		Project: RCRA CERCLA drilling, FY 2004				
Prepared By: Charlene Martinez		Date: 06/04/04		Reviewed By: L.D. Walker		
Signature: Charlene Martinez		Date: 6/10/04				
Signature: L.D. Walker						
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA				
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description		
10 5/8" OD temporary casing set to 265' bgs		0		0-0.3' Crushed gravel (drilled)		
				0.3'-23' SAND(S)		
6" ID ss protective casing set + 1.09' above permanent					23'-26' gravelly SAND(gS)	
					26'-40' SAND(S)	
4" ID ss riser (schedule 5); + 2.05' → 275.1'				40	40'-58' slightly silt gravelly sand(mgS)	
					58'-78' SAND(S)	
Portland Cement Grout: 11' → 0'					68' silt lens (ca. 3' thick)	
				80	78'-90' slightly silt gravelly sand (mgS)	
Granular Bentonite: 11' → 245.6'					90'-115' gravelly SAND(gS)	
					115'-252' SAND(S)	
				120		
				160		
				200		
All depths in feet below ground surface:						
All temporary casing removed from ground.						

Figure C-3. Well 299-E24-33 Construction and Completion Summary (1 of 2)

WELL SUMMARY SHEET		Start Date: 04/16/04	Page 3 of 3
		Finish Date: 06/02/04	
Well ID: C4257		Well Name: 299-E24-33	
Location: west of AX Tank Farm/200 East		Project: RCRA/CERCLA drilling, FY2004	
Prepared By: Charles Martinez	Date: 06/02/04	Reviewed By: L.D. Walker	Date: 6/10/04
Signature: Charles Martinez		Signature: L.D. Walker	
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description
9 5/8" OD carbon steel casing set from 265' - 315'		240	252' - 255.5' sandy GRAVEL (SG)
Portland Cement Grout: 245.6' → 264.7'		255.5' - 262.5' SILT (m)	
3/8" Bentonite Pellets: 264.7' → 269.4'		267.5' - 268.5' sandy SILT (SM)	
10-20 mesh Colorado silica sand 269.4' → 315.4'		268.5' - 274' silty sandy GRAVEL (msG)	
4" to 35 304, sched. 5, 0.020-inch slit well screen: 275.1' → 310.1'		274' - 275' SAND (S)	
4" 20 55 304, sched. 5 sump: 310.1' → 313.1'		275' - 280' sandy GRAVEL (SG)	
		280' - 290' SAND (S)	
		290' - 292' silty sandy GRAVEL (msG)	
		292' - 313' sandy GRAVEL (SG)	
		313' - 315.4' silty sandy GRAVEL (msG)	
	TD = 315.4' bgs		
	static water @ 274.35' bgs (06/02/04)		
All depths in feet below ground surface.			
All temporary casing removed from ground.			

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Figure C-3. Well 299-E24-33 Construction and Completion Summary (2 of 2)

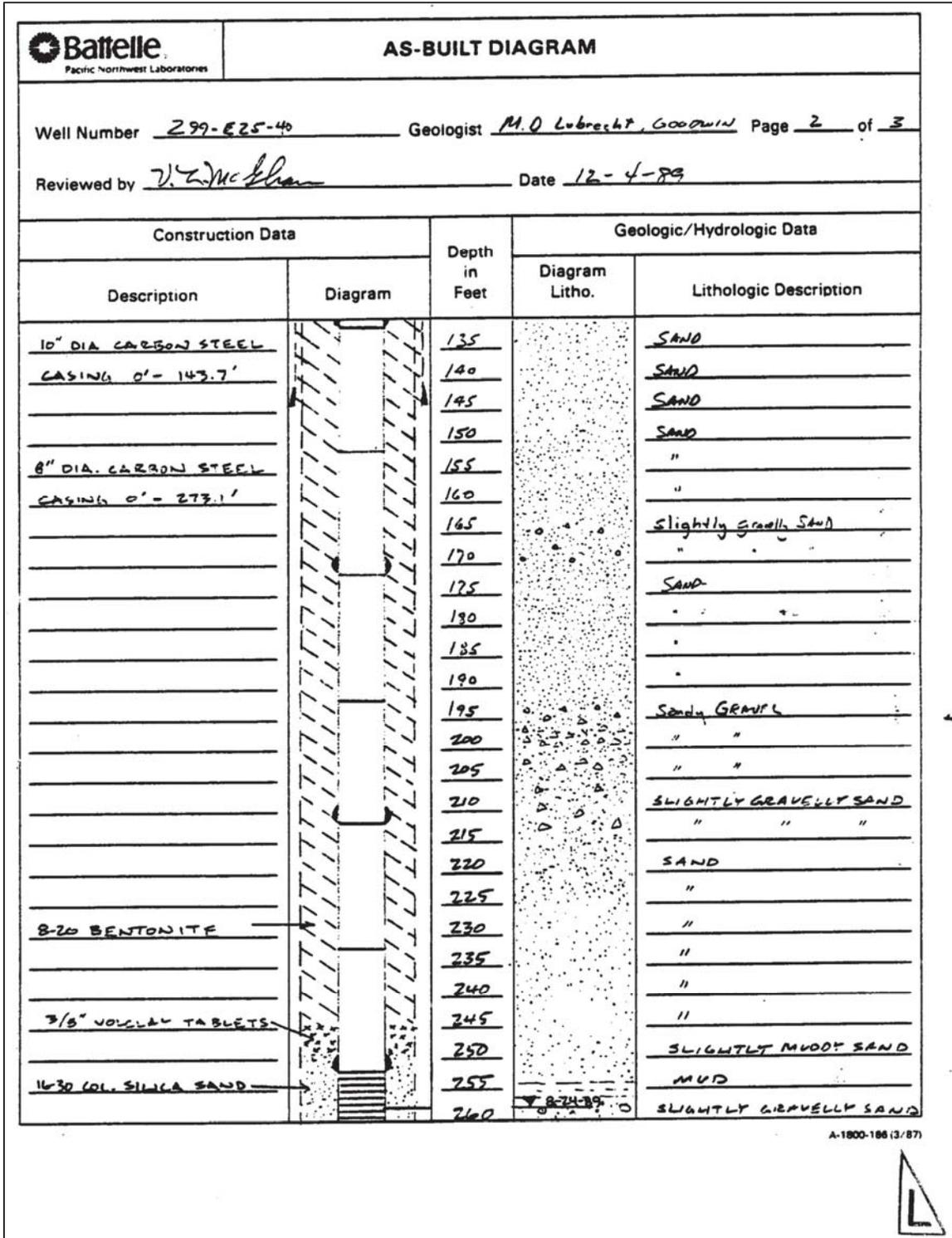


Figure C-4. Well 299-E25-40 Construction and Completion Summary (2 of 3)

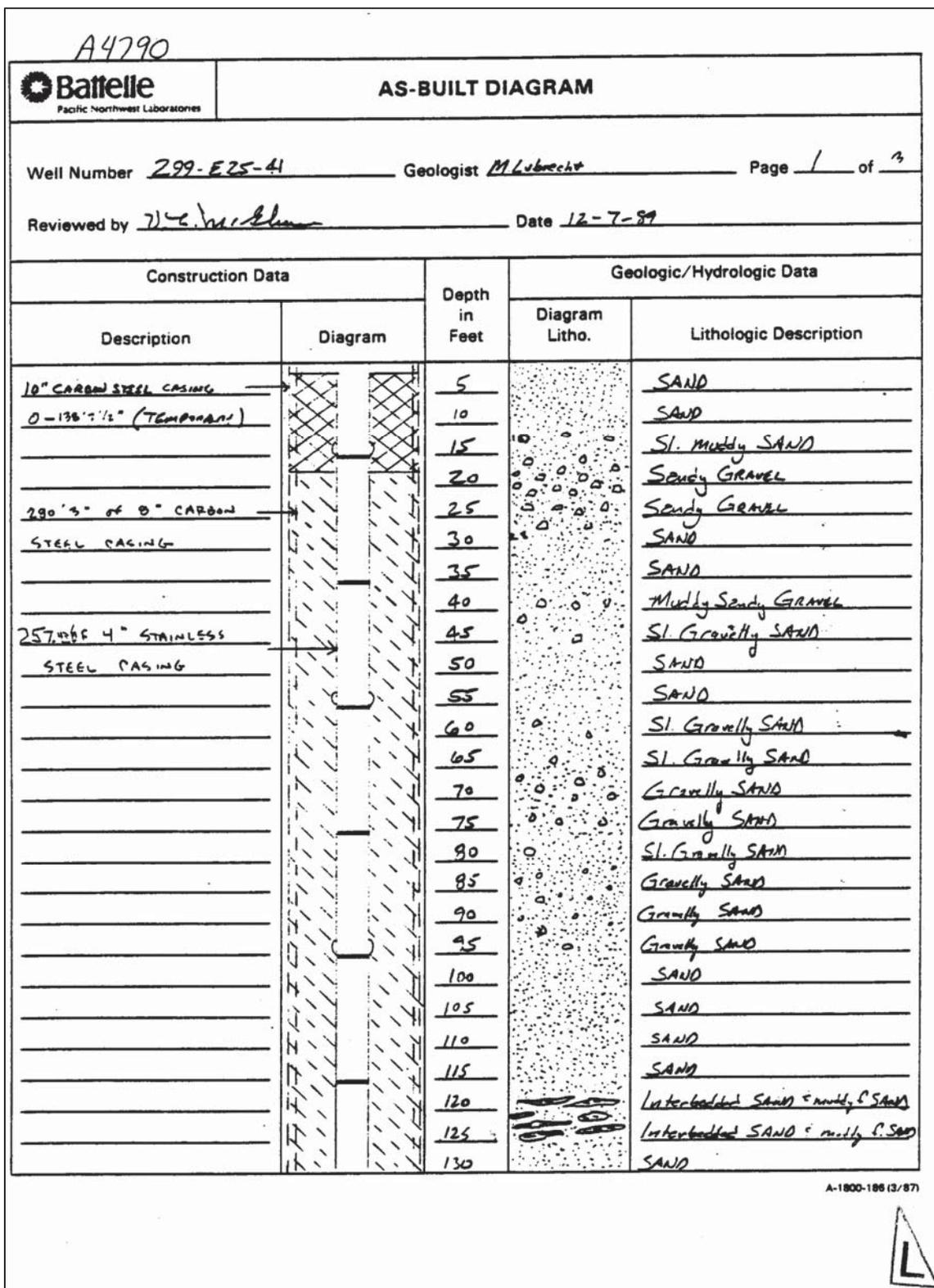


Figure C-5. Well 299-E25-41 Construction and Completion Summary (1 of 3)

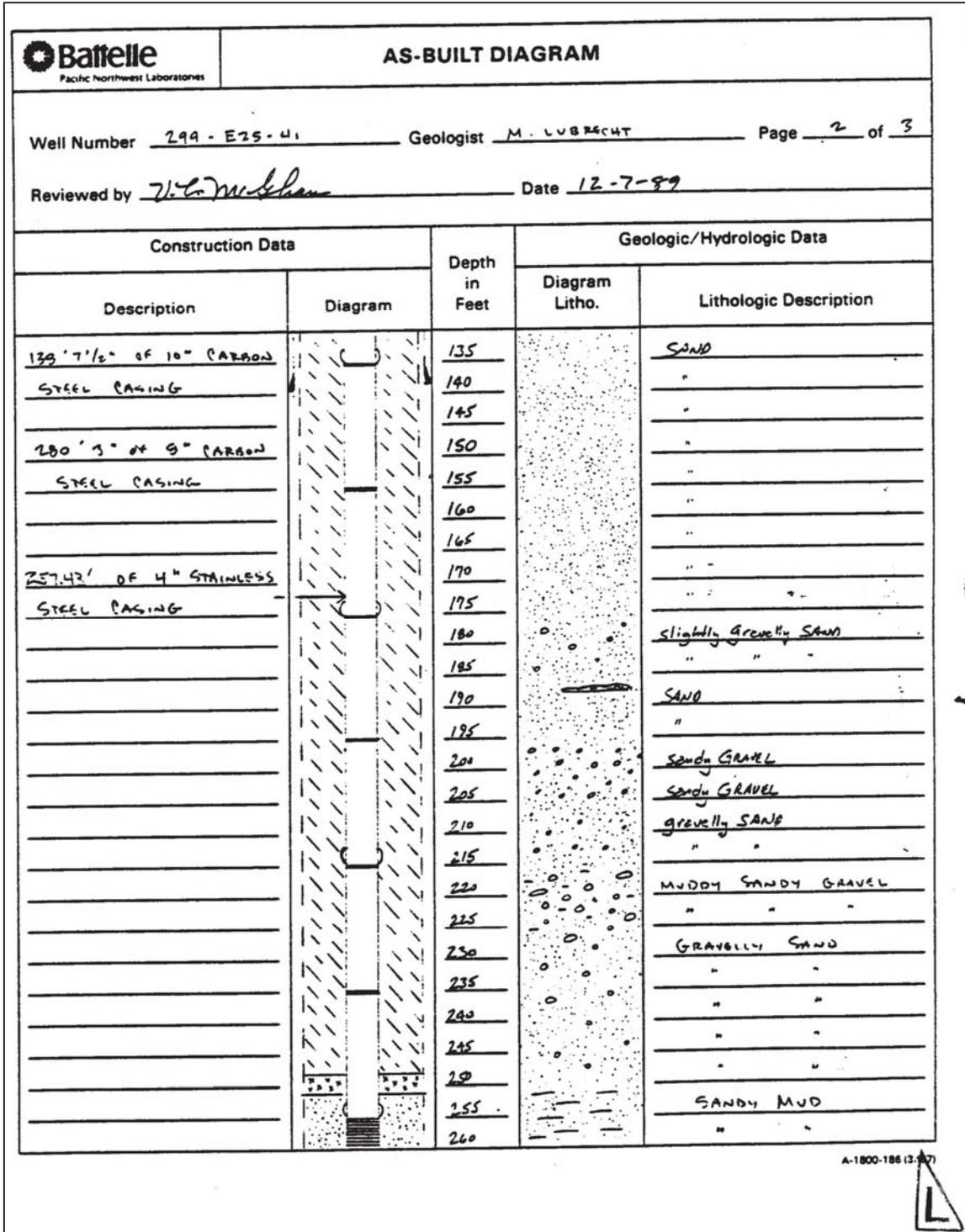


Figure C-5. Well 299-E25-41 Construction and Completion Summary (2 of 3)

Construction Data		Depth in Feet	Geologic/Hydrologic Data	
Description	Diagram		Diagram Litho.	Lithologic Description
280' 3" of 6" CARBON STEEL CASING		265		SANDY MUD
		270		MUDDY SANDY GRAVEL
		275		SANDY GRAVEL
2101' of 4" CHANNEL PACK SCREEN (10 SLOT)				
COMPLETION SYMBOLS:				
	CEMENT GROUT			
	BENTONITE CRUMBS			
	BENTONITE PELLETS			
	SILICA SAND			
	CASING JOINT			
	CASING CENTRALIZER			

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Figure C-5. Well 299-E25-41 Construction and Completion Summary (3 of 3)

WELL SUMMARY SHEET		Start Date: 07/01/03		Page 1 of 2	
		Finish Date: 07/09/03			
Well ID: C-4122		Well Name: 299-E25-93			
Location: EAST OF 241-A Tank Farm		Project: C-403 RCRA Drilling			
Prepared By: Charlene Martinez		Date: 07/15/03		Reviewed By: L.D. Walker	
Signature: <i>Charlene Martinez</i>		Signature: <i>L.D. Walker</i>			
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA			
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description	
Dual-wall temporary casing used. 9" OD. Inner casing 1/6"		0		0'-2' Backfill material	
Protective casing set (6" ID) + 1.11' above permanent casing				2'-11" SAND(S)	
4" ID SS 304 sched 10 casing: 12.00' → 278.23'				Hanford Formation @ 11' bgs.	
Portland Cement Grout: 0' → 10.5'				4'-20" SAND(S)	
Granular Bentonite: 10.5' → 268.5'				20'-25" Gravelly SAND(qs)	
1/4" Bentonite Pellets: 268.5' → 273.1'				25'-35" SAND(S)	
All temporary casing removed from ground.				35'-45" Gravelly SAND(qs)	
All depths are in feet below ground surface.				45'-106" SAND(S)	
				106'-115" Gravelly SAND(qs)	
				115'-215" SAND(S)	
				215'-220" gravelly SAND(qs)	
				220'-266" SAND(S)	

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Figure C-6. Well 299-E25-93 Construction and Completion Summary (1 of 2)

WELL SUMMARY SHEET		Start Date: 07/01/03		Page 2 of 2	
		Finish Date: 07/09/03			
Well ID: C-4122		Well Name: 299-E25-93			
Location: East of 241-A Tank Farm		Project: CY03 RCRA drilling			
Prepared By: Charlene Martinez		Date: 07/15/03		Reviewed By: L.D. Walker	
Signature: Charlene Martinez		Signature: L.D. Walker			
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA			
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description	
10-20 mesh silica sand: 273.1' → 320.0'		240		276 - 317' sandy GRAVEL (SG)	
4" ID SS 304 schedule 10 well screen: .020 SLOT 278.23' → 313.26'		280		Ringold formation @ 307' bgs	
4" ID SS 304 schedule 10 sumplendcap 313.26' → 315.26'		320		317-320' silty sandy GRAVEL (mG)	
				TD @ 320' bgs. static water @ 278.04' bgs (07/15/03)	
All temporary casing removed from ground.					
All depths are in feet below ground surface.					

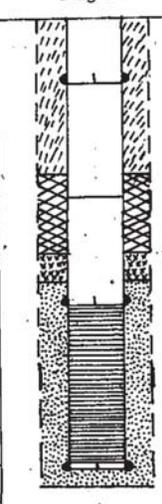
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Figure C-6. Well 299-E25-93 Construction and Completion Summary (2 of 2)

WELL SUMMARY SHEET		Start Date: 09-13-04	Page 1 of 2
Well ID: C4665		Well Name: 299-E25-94	
Location: NE Corner of 242-A Evap. Parking Lot		Project: RCRA CY04 Monitoring Wells	
Prepared By: Jess Hocking	Date: 9/27/04	Reviewed By: L.D. Walker	Date: 10-13-04
Signature: <i>Jess Hocking</i>		Signature: <i>L.D. Walker</i>	
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description
4" sch. Ss TP-304/304L Riser 0.5' → 295.1'		0	0-4' DRILL PAD / MISC. FILL MATERIAL
4" sch. Ss TP-304/304L 295.1' → 330.1'		4-44' Sand (S)	
4" sch. Ss TP-304/304L Sump 330.1' → 331.1'		44-45' Silt (M)	
10-20 mesh Colorado Silica Sand 333' → 288'		45-70' Sand (S)	
5/8" Wyoming Bentonite Pellets 288' → 282'		70-77' Slightly silty sand ((m)S)	
Portland Cement 282' → 267'		77-85' Slightly silty gravelly sand ((m)S)	
Pure Wyoming Bentonite Crumbles 267' → 13'		85-120' Slightly silty sand ((m)S)	
Portland Cement 13' → 3'		120-140' Sand (S)	
10" diameter temporary drill casing driven to 332' bgs		140-145' Slightly silty sand ((m)S)	
		145-150' Sand (S)	
		150-160' Silty Sand (mS)	
		160-175' Slightly silty sand ((m)S)	
		175-185' Sand (S)	
	185-195' Slightly silty sand ((m)S)		
	195-230' Sand (S)		
	230-235' Slightly silty sand ((m)S)		
	235-268' Sand (S)		

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Figure C-7. Well 299-E25-94 Construction and Completion Summary (1 of 2)

WELL SUMMARY SHEET		Start Date: 09-13-04	Page 2 of 2	
		Finish Date: 9-27-04		
Well ID: C4665		Well Name: 299-E25-94		
Location: NE Corner of 242-A Evap. Parking Lot.		Project: RCRA CY04 Monitoring Wells		
Prepared By: Jess Hocking	Date: 9/27/04	Reviewed By: L.D. Walker	Date: 10/13/04	
Signature: <i>Jess Hocking</i>		Signature: <i>L.D. Walker</i>		
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Lithologic Description	
		240		
			268-268.5' Gravelly Sand (gS)	
			268.5-270' Gravelly silty sand (gms)	
			270-271.7' Silty sand (ms)	
			271.7-280' Silt (M)	
			280-285.5' Gravelly sand (gS)	
			285.5-288' Sandy gravel (sG)	
			288-296' Silty sandy gravel (msG)	
			296-325' Sandy gravel (sG)	
			325-330' Slightly silty gravelly sand (sigs)	
			330-333' Gravelly sand (gS)	
			333=TD Silty Sandy gravel (msG)	
			360	
				TD = 333' bgs (9/23/04)
				DTW = 295.6' bgs (9/21/04)
NOTE: ALL TEMPORARY CASING HAS BEEN REMOVED FROM THE GROUND.				

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Figure C-7. Well 299-E25-94 Construction and Completion Summary (2 of 2)

WELL SUMMARY SHEET		Start Date: 11-10-2014	Page 1 of 3
		Finish Date: 1-19-2015	
Well ID: C8922		Well Name: 299-E25-237	
Location: S. of WMA A-AX		Project: M24 Drilling	
Prepared by: Julie Johanson	Date: 12-17-14	Reviewed by: J.D. MEHRER	Date: 1/21/15
Signature: <i>Julie Johanson</i>		Signature: <i>J.D. Mehrer</i>	
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description
<p>Surface Completion: 4'x4'x6" Concrete Pad with brass survey marker and 6 9/16" protective monument (3.00' ags)</p> <p>Well Completion material: High Strength Concrete 0.0' bgs - 2.8' bgs</p> <p>Type I/II Portland Cement 2.8' bgs - 10.42' bgs</p> <p>Granular Bentonite (Medium Chips, 8-20 Crumbles, 3/4" Chunks) 10.42' bgs - 285.43' bgs</p> <p>3/8" Bentonite Pellets 285.43' bgs - 287.27' bgs</p> <p>10-20 Colorado Silica Sand 287.27' bgs - 332.3' bgs</p> <p>3/8" Bentonite Pellets 332.3' bgs - 334.1' bgs</p> <p>3/4" Bentonite Chunks 334.1' bgs - 372.04' bgs</p> <p>Natural Fill 372.04' bgs - 374.78' bgs</p> <p>Permanent Well: 4" ID PVC Blank 1.98' ags - 291.00' bgs</p> <p>4" ID Stainless Steel 0.020 Slot Screen 291.00' bgs - 326.00' bgs</p> <p>4" ID Stainless Steel Sump 326.00' bgs - 329.02' bgs</p> <p>All temporary casing completely removed from ground on 1/15/2015</p> <p>ags = above ground surface bgs = below ground surface</p>		<p>0</p> <p>0-0.5: Gravelly Sand (gS) Drill Pad. 0.5-9: Sand (S)</p> <p>9-18: Gravelly Sand (gS)</p> <p>18-30: Sand (S)</p> <p>25</p> <p>30-36: Gravelly Sand (gS)</p> <p>36-58: Sandy Gravel (sG)</p> <p>50</p> <p>58-70: Sand (S)</p> <p>75</p> <p>70-75: Gravelly Sand (gS)</p> <p>75-80: Sandy Gravel (sG)</p> <p>80-90: Gravelly Sand (gS)</p> <p>90-100: Sandy Gravel (sG)</p> <p>100</p> <p>100-105: Gravelly Sand (gS)</p> <p>105-120: Sandy Gravel (sG)</p> <p>125</p> <p>120-123: Slightly Silty Gravelly Sand((m)gS) 123-167: Sand (S)</p>	

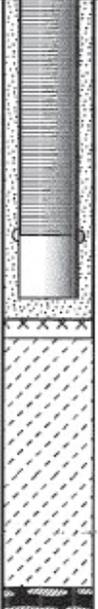
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Figure C-8. Well 299-E25-237 Construction and Completion Summary (1 of 3)

WELL SUMMARY SHEET		Start Date: 11-10-2014	Page 2 of 3	
Well ID: C8922		Finish Date: 1-19-2015		
Location: S. of WMA A-AX		Well Name: 299-E25-237		
Prepared by: Julie Johanson	Date: 12-17-14	Project: M24 Drilling	Reviewed by: J.D. MEHRER	
Signature: <i>Julie Johanson</i>		Date: 1/21/15		
Signature: <i>J.D. Mehrer</i>		Signature: <i>J.D. Mehrer</i>		
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Lithologic Description	
Well Completion material:		150	123-167: Sand (S)	
High Strength Concrete 0.0' bgs - 2.8' bgs				
Type I/II Portland Cement 2.8' bgs - 10.42' bgs				
Granular Bentonite (Medium Chips, 8-20 Crumbles, 3/4" Chunks) 10.42' bgs - 285.43' bgs				
3/8" Bentonite Pellets 285.43' bgs - 287.27' bgs				
10-20 Colorado Silica Sand 287.27' bgs - 332.3' bgs				
3/8" Bentonite Pellets 332.3' bgs - 334.1' bgs				
3/4" Bentonite Chunks 334.1' bgs - 372.04' bgs				
Natural Fill 372.04' bgs - 374.78' bgs				
Permanent Well:				
4" ID PVC Blank 1.98' ags - 291.00' bgs				
4" ID Stainless Steel 0.020 Slot Screen 291.00' bgs - 326.00' bgs				
4" ID Stainless Steel Sump 326.00' bgs - 329.02' bgs				
			225	220-230: Slightly Silty Sand ((m)S)
				230-235: Sand (S)
			235-243: Slightly Silty Sand ((m)S)	
			243-248: Slightly Silty Gravelly Sand((m)qS)	
		250	248-278: Sand (S)	
		275	278-280.7: Sandy Silt (sM)	
			280.7-290: Gravelly Silty Sand (gmS)	
			290-305: Silty Sandy Gravel (msG)	
			DTW: 295.36' bgs	

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Figure C-8. Well 299-E25-237 Construction and Completion Summary (2 of 3)

WELL SUMMARY SHEET		Start Date: 11-10-2014	Page 3 of 3
		Finish Date: 1-19-2015	
Well ID: C8922		Well Name: 299-E25-237	
Location: S. of WMA A-AX		Project: M24 Drilling	
Prepared by: Julie Johanson	Date: 12-17-14	Reviewed by: J.D. MEHRER	Date: 1-21-15
Signature: <i>Julie Johanson</i>		Signature: <i>J.D. Mehrer</i>	
CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description
<p>Well Completion:</p> <p>High Strength Concrete 0.0' bgs - 2.8' bgs</p> <p>Type I/II Portland Cement 2.8' bgs - 10.42' bgs</p> <p>Granular Bentonite (Medium Chips, 8-20 Crumbles, 3/4" Chunks) 10.42' bgs - 285.43' bgs</p> <p>3/8" Bentonite Pellets 285.43' bgs - 287.27' bgs</p> <p>10-20 Colorado Silica Sand 287.27' bgs - 332.3' bgs</p> <p>3/8" Bentonite Pellets 332.3' bgs - 334.1' bgs</p> <p>3/4" Bentonite Chunks 334.1' bgs - 372.04' bgs</p> <p>Natural Fill 372.04' bgs - 374.78' bgs</p> <p>Permanent Well:</p> <p>4" ID PVC Blank 1.98' bgs - 291.00' bgs</p> <p>4" ID Stainless Steel 0.020 Slot Screen 291.00' bgs - 326.00' bgs</p> <p>4" ID Stainless Steel Sump 326.00' bgs - 329.02' bgs</p>		<p>300</p> <p>305-306: Sand (S)</p> <p>306-345.78: Silty Sandy Gravel (msG)</p> <p>325</p> <p>345.78-366.19: Silty Sandy Gravel (msG) (Hard tool Slurry)</p> <p>350</p> <p>366.19-374.5: Silty Sandy Gravel (msG)</p> <p>375</p> <p>374.5-375: Basalt</p> <p>ID: 374.78' bgs</p>	

A 2

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Figure C-8. Well 299-E25-237 Construction and Completion Summary (3 of 3)

C2 References

- NAD83, 1991, *North American Datum of 1983*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: <http://www.ngs.noaa.gov/>.
- NAVD88, 1988, *North American Vertical Datum of 1988*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: <http://www.ngs.noaa.gov/>.

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